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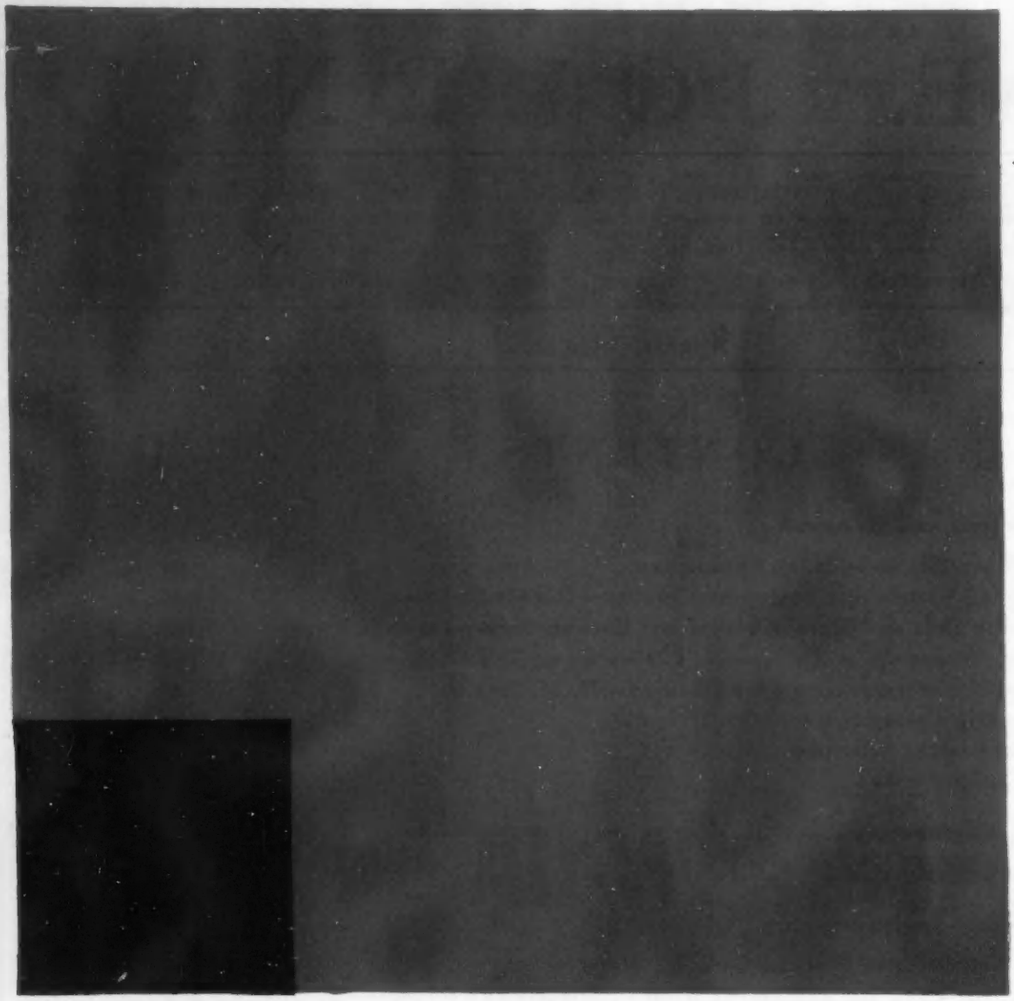
The purpose of meetings of the Society is largely to provide a forum for the presentation of straightforward and frank discussion. Discussion of this kind is encouraged. However, owing to the nature of the Society as an organization, it cannot be responsible for statements or opinions advanced in papers or in discussions at its meetings. The Constitution of the Society has long contained a provision to this effect.



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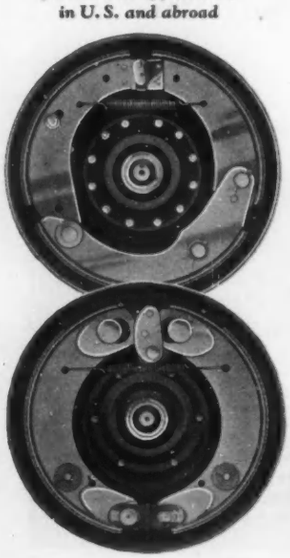

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BENDIX

S. A. E. JOURNAL

Vol. XXV August, 1929 No. 2

Aeronautic Meeting, Aug. 26 to 28

Cleveland Sessions To Be Held with Aeronautical Chamber of Commerce During National Air Races and Exposition

THE AIRMINDEDNESS of Cleveland undoubtedly will be accentuated and receive a decided impetus during the last week in August and the early days of September, because at that time Cleveland will be host to the 1929 National Air Races, the Aeronautical Exposition and the joint Aeronautic Meeting of the Aeronautical Chamber of Commerce of America and the Society. The races, which promise to be of exceptional interest this year, will be run between Aug. 24 and Sept. 2; and in conjunction with the races the Aeronautical Exposition will be staged in the Cleveland Municipal Auditorium. The joint engineering meeting of the Chamber and the Society will be held at the Hollenden Hotel on Aug. 26, 27 and 28, the cooperative feature of the meeting being in accordance with the policy established last year. Sessions will be open to members of both organizations and also to nonmembers.

A glance at the technical program on p. 105 will show that the joint meeting of the Chamber and the Society is intended for *aeronautical* engineers. Keen and worthwhile discussion of the various papers is to be expected, as advance copies of available papers will be sent, upon request, to members who particularly desire to read them before the meeting.

Six Sessions Scheduled

Opening with a Standards Session on Monday morning, Aug. 26, the program will present thereafter five technical sessions, devoted respectively to propellers, powerplants, airplane design, transportation and light alloys.

From a viewpoint of interest to the largest number of aeronautical engineers, the Powerplant Session should draw a particularly good attendance. Gaging engine performance is a subject that is becoming more important with the acceptance by industry of each new engine; therefore the opinions of J. H. Geisse, until recently chief engineer of the aeronautic engine laboratory of the Naval Aircraft Factory and now vice-president of engineering of the Comet Engine Corp., on this question will be welcome. Lively discussion unquestionably will follow the presentation of his paper, as copies will be sent in advance to every engine builder.

Of equal interest will be the discussion of liquid cooling, scheduled for this same session. The principal paper on this topic will be by G. W. Frank, of Wright Field, and prepared discussion is to be presented by Mr. Geisse. Both speakers have conducted research on high-temperature liquid-cooling for the Army and the Navy, respectively, and the technical details of this development, which has a great bearing on the future of the liquid-cooled engine, will be appreciated by the industry.

The Propeller Session will interest equally the aircraft and the powerplant engineers. The first part of the session will be devoted to a symposium on variable-pitch propellers, papers being submitted by Theodore P. Wright, chief engineer of the airplane division of the Curtiss Aeroplane & Motor Co., and W. R. Turnbull, consulting engineer for the same company, and Frank W. Caldwell, of the Standard Steel Propeller Corp. Future developments aiming at increased propeller efficiency by some means of varying the pitch of the blades will be of importance to every aeronautical engineer, and it is hoped that the discussion will bring out information regarding recent developments along other lines than those followed by the speakers. A third paper to be presented at this session will be Gearing of Propellers, by Theodore P. Wright and R. E. Johnson, of the Curtiss Aeroplane & Motor Co.

Papers on Airplane Design

Airplane designers will welcome the paper on Wings, a Coordinated System of Basic Design, to be presented at the Airplane-Design Session by Ralph H. Upson, of the Aeromarine Klemm Corp. This paper develops simple formulas for calculating the effect of various factors involved in the design of wings and presents charts by which wing design can be selected to meet any set of requirements. These data will be of great value to plane designers interested in obtaining the best possible design for given conditions without going through the large amount of calculation usually involved.

The S.A.E. Aeronautic Committee, of which Capt. E. S. Land is chairman, has compiled a list of aeronautic designers who will be asked to submit prepared discussion of Mr. Upson's paper, copies of which will be available shortly.

The companion paper for presentation at the Airplane-Design Session will be by Prof. A. S. Niles, of Leland Stanford, Jr., University, on Load Factors for Aircraft Structures and Load Tests vs. Stress Analyses as a Basis for Design Approval.

Mac Short, of the Stearman Aircraft Co., has been asked to serve as chairman of this session. Mr. Short is chairman of the Organization Committee elected by Society members in Wichita to organize a Wichita Aeronautic Section of the Society. At the organization meeting in June, more than 40 members and guests had the pleasure of hearing a characteristically interesting talk by W. B. Stout, the Society's Second Vice-President for aviation engineering.

Autogyro Inventor to Talk

Captain Land's committee is to be congratulated on arranging for Juan de la Cierva to talk at the Transportation Session. Senor de la Cierva, who is coming to this Country just before the National Air Races, will be introduced by H. F. Pitcairn, whose company holds the American rights for the Autogyro. The Autogyro has attracted widespread attention and is of special interest as the leading contender for recognition as the fool-proof airplane, being able, with a properly designed landing-gear, to descend at a very sharp angle without the aid of the powerplant.

Members interested in the merchandising of airplanes will want to hear R. L. Putman's paper on The Selling of Airplanes to Business Houses. It is

believed that all attending the meeting, including the less technically minded, will enjoy Mr. Putman's address.

The Economic Relationship of Speed and Weight in Air Transportation is the title of an extremely informative paper that is to be presented by Edward P. Warner, former Assistant Secretary of the Navy and now editor of *Aviation*.

W. B. Stout, president of the Stout Air Services, will talk on the Load Rating of Commercial Airplanes, a subject of extraordinary importance.

A Symposium on Beryllium

Glenn L. Martin has been quoted as saying that, if a house were made of beryllium, he could make it fly. This picturizes the potential value of beryllium for aircraft, a subject on which a symposium has been scheduled for the Light-Alloys Session, the concluding

J. H. GEISSE

event of the meeting. Outstanding authorities, whose investigations of the subject have been of such nature and scope as to give them a practical as well as theoretical knowledge of these alloys, will participate in the symposium, chief among the discussers being Dr. W. L. Fink, of the Aluminum Co. of America; H. S. Rawdon, of the Bureau of Standards; Dr. J. E. Harris, of Bell Telephone Laboratories; and Mr. Sawyer, of the C. F. Brush Laboratories. H. S. Cooper, of the Beryllium Corp. of America, has consented to exhibit at the meeting a number of specimens of beryllium and a few of its interesting alloys, which he will discuss.

An interesting and comprehensive paper to be presented by E. H. Dix, of the Aluminum Co. of America, at the same session, will deal with the extremely important topic, Characteristics and Prevention of Corrosion of Strong Light Alloys.

Another subject which is very important in itself and unusually pertinent at this time is that of welding aircraft parts. The Aeronautic Committee has been fortunate in securing the consent of R. M. Mock, aernoautical engineer of the Bellanca Aircraft Corp., to present a paper on this topic.

To Consider Standards Requirements

Present aircraft standards and new items on which standardization is necessary are to be discussed at the Standards Session. R. B. C. Noorduyn,

R. H. UPSON

Chairman of the Standards Committee of the Aeronautical Chamber of Commerce, appointed to cooperate with the Society, has been invited to talk on standards requirements as viewed by manufacturers.

The Aircraft-Lighting Committee, which is conducting a research into airplane landing-light requirements, will exhibit a complete set of the equipment that is about to be installed in airplanes for test purposes and will open the subject for discussion to obtain suggestions and criticisms which may serve as a guide in this work.

Inspection Trip to Goodyear

In addition to the technical sessions scheduled, arrangements have been made to give the members and guests of the Chamber and the Society an opportunity to visit the plant of the

J. C. HUNSAKER

Goodyear-Zeppelin Corp. at Akron, Ohio, where an inspection visit of unusual attractiveness is assured.

Cleveland Section Cooperating

W. E. England, Chairman of the Cleveland Section, will be chairman of the local committees that will assist in making the Cleveland Aeronautic Meeting a splendid success.

Hotel Accommodations

Notwithstanding its excellent facilities, Cleveland will surely be a very crowded city during the last week in August. Therefore all who plan to attend the joint Aeronautic Meeting of the Aeronautical Chamber of Commerce and the Society are urged to arrange for hotel accommodations in ample time to avoid disappointment and last-minute confusion.

National Meetings

Cleveland Aeronautic—Aug. 26 to 28
Hollenden Hotel, Cleveland

Motorboat—September
During Motorboat Regatta, Detroit

Production—Oct. 2 to 4
Hotel Cleveland, Cleveland

Transportation—Nov. 12 to 15
The Royal York, Toronto

Annual Dinner—Jan. 9, 1930
New York City

Annual—Jan. 21 to 24, 1930
Book-Cadillac Hotel, Detroit

St. Louis Aeronautic—Feb., 1930

Detroit Aeronautic—April, 1930

Technical Program of Cleveland Aeronautic Meeting

of the

Society of Automotive Engineers, Inc., and the Aeronautical Chamber of Commerce of America, Inc.

Hollenden Hotel, August 26 to 28

Monday, Aug. 26

10 A.M.—STANDARDS SESSION

2 P.M.—PROPELLER SESSION

E. T. Jones, *Chairman*

Chief Powerplant Engineer, Wright Aeronautical Corp.

The Controllable-Pitch Propeller—Theodore P. Wright, Chief Engineer, Airplane Division, Curtiss Aeroplane & Motor Co., Inc., and W. R. Turnbull, Consulting Engineer, Curtiss Aeroplane & Motor Co., Inc.

Variable-Pitch Propellers—Frank W. Caldwell, Consulting Engineer, Standard Steel Propeller Corp.

Gearing of Propellers—Theodore P. Wright, Chief Engineer, Airplane Division, Curtiss Aeroplane & Motor Co., Inc., and R. E. Johnson, Curtiss Aeroplane & Motor Co., Inc.

8:30 P.M.—POWERPLANT SESSION

L. M. Woolson, *Chairman*

Aeronautical and Research Engineer, Packard Motor Car Co.

Gaging Engine Performance—J. H. Geisse, Vice-President of Engineering, Comet Engine Corp.

High-Temperature Liquid-Cooled Engines—G. W. Frank, Associate Mechanical Engineer, Powerplant Branch, Materiel Division, Army Air Corps, Wright Field.

Prepared discussion by J. H. Geisse.

Tuesday, Aug. 27

10 A.M.—AIRPLANE-DESIGN SESSION

Mac Short, *Chairman*

Chief Engineer, Stearman Aircraft Co.

Wings, a Coordinated System of Basic Design—Ralph Upson, Aeromarine Klemm Corp.

Prepared discussion by Designers.

Load Factors for Aircraft Structures, and Load Tests versus Stress Analyses as a Basis for Design Approval—Prof. A. S. Niles, Leland Stanford, Jr., University.

2 P.M.—GOODYEAR INSPECTION TRIP TO AKRON

8 P.M.—TRANSPORTATION SESSION

Capt. E. S. Land, *Chairman*

Vice-President and Treasurer, Daniel Guggenheim Fund for the Promotion of Aeronautics, Inc.

The Autogyro—Juan de la Cierva.

Selling Airplanes to Business Houses—Russell L. Putman.

Economic Relationship of Speed and Weight in Air Transportation—Edward P. Warner, Editor, *Aviation*.

Load Rating of Commercial Airplanes—W. B. Stout, President, Stout Air Services, Inc.

Wednesday, Aug. 28

10 A.M.—LIGHT-ALLOYS SESSION

J. C. Hunsaker, *Chairman*

Vice-President, Goodyear-Zeppelin Corp.

Beryllium Alloys—Discussion by Dr. W. L. Fink, Aluminum Co. of America; H. S. Rawdon, Bureau of Standards; Dr. J. E. Harris, Bell Telephone Laboratories; and Mr. Sawyer, C. F. Brush Laboratories.

Characteristics and Prevention of Corrosion of Strong Light Alloys—E. H. Dix, Jr., Aluminum Co. of America.

Prepared discussion to be presented.

Welding Aircraft Parts—R. M. Mock, Aeronautical Engineer, Bellanca Aircraft Corp.

The first of two MEETINGS BULLETINS telling about the Cleveland Aeronautic Meeting was mailed on July 22. The list of papers to be presented was in the form of a return-blank on which members could request copies of papers they desired to study prior to the meeting. A number of the papers are expected to be available about two weeks before the meeting. The S.A.E. Aeronautic Committee urges members to come to the meeting prepared to discuss the papers. As general discussion is often of even more value than the papers themselves, ample time will be allowed for such discussion. It is felt that meetings are not justified merely for the presentation and subsequent publication of papers. The holding of meetings for the purpose of open discussion is the function of an association; the publication of papers, either by the association or the trade press, being of secondary importance.

Chronicle and Comment

Forthcoming Volumes of S.A.E. Transactions

AS this issue of the S.A.E. JOURNAL is being mailed, Vol. 23 of the S.A.E. TRANSACTIONS goes to press. This volume, which contains 72 of the papers printed in THE JOURNAL for the year 1928 and regarded by the Publication Committee as possessing sufficient engineering merit to warrant reprinting in the permanent record of the Society, combines in a single cover the two regular Parts of S.A.E. TRANSACTIONS for last year. The decision to publish the two parts in a single volume was made for the sake of economy and speed of production.

Present indications are that copies will be mailed some time in September to those members who placed orders for Part I. A limited number of copies of the complete volume will be available to members who did not order Part I and can be secured by writing to the office of the Society in New York City promptly.

Order blanks for Part I of Vol. 24 of the S.A.E. TRANSACTIONS, covering the first six months of the current year, have been sent to the membership. Oct. 1 is the closing date for the receipt of orders for this Part, which is scheduled for mailing on Nov. 15.

1929 Handbook Supplement

THE semi-annual Supplement revising the 1929 edition of the S.A.E. HANDBOOK will be mailed to the members on or before Aug. 15. This Supplement contains 19 revised specifications, 15 new aeronautic specifications and 12 automobile and kindred specifications.

The Supplement will appear in a new dress with a more substantial cover and will be published about six weeks earlier than usual. It is anticipated that placing the new and revised standards in the hands of the members so soon after adoption will be of benefit.

Variety in Automotive Engineering

ONE of the reasons for the fascination that automotive engineering holds for so many engineers, whether old, young or in the prime of life, is its great variety. This is reflected in the present number of the S.A.E. JOURNAL. Among the papers contained in it are several on automobile and aeronautic engines, one on valve design, three on fuels, one on automobile bodies, discussion on airplane spinning, a paper on the possibilities of a new development in aviation, one on airplane construction, one on airport design, one on motorboat hulls, one on motor-truck operation and one on motorcoach maintenance. Thus the content of this one issue is diversified into major classes of land, air and water vehicles powered with internal-combustion engines; and into sub-classes of research, design, and operation; engines; fuels; bodies, hulls and fuselages; and ground facilities for the commercial use of airplanes.

This is typical of the automotive engineering field, which has ramifications into innumerable branches of science, engineering, manufacturing, and commerce.

Somewhere in this broad field almost anyone having a scientific, mechanical or commercial bent and training can find a favorable outlet for his efforts in a line of activity that is unusually progressive and has a most promising future. Few fields offer such diversified opportunities to graduates of scientific, engineering and business educational courses who are now about to step across the threshold into their adult careers.

Sets of *Daily SAE* Available

A LIMITED number of complete sets of the *Daily SAE* issued during the Summer Meeting at Saranac Inn are available to members who would like to have a set. Requests should be addressed to the advertising department of the Timken Roller Bearing Co., Canton, Ohio. Only a few sets are left, and those who write for them most promptly will be least likely to be disappointed.

Standardization of Twist Drills

TWO important proposals, drafted by a Technical Committee of the Sectional Committee on Standardization of Small Tools and Machine-Tool Elements, for which the Society is one of the sponsors, are submitted in this issue of THE JOURNAL, commencing on p. 180. As twist drills are in every-day use and are an important item in the tool inventories of the mechanical manufacturing industries, it is essential that this proposal be given careful consideration. The industries are asked to indicate which of the two proposals submitted should be chosen for adoption as the American Standard for Straight-Shank Twist-Drills.

Capacity Plates on Fuel Tanks

IN A LETTER from Brisbane, Australia, George A. C. Leaver, A.S.A.E., suggests that the idea of indicating on motor-vehicles the capacity of the gasoline tank, the crankcase, the radiator, the transmission case and the differential housing, as advocated by *Petroleum Age* in an editorial reprinted in the S.A.E. JOURNAL for May, 1929, p. 404, is basically sound and would stand amplification. He writes in part:

> "Not a week passes without my having to give, through the press, the inch-to-gallon measurements (of the fuel tanks) of at least two or three cars. Why not persuade the tank makers to fit a small plate to the tank giving these measurements in Imperial gallons for Australia and other countries using the Imperial measure?
>
> "Such a move would cost only cents and would be the means of saving many hours' delay, due to petrol hold-up, for which the motorist would certainly be grateful. It would, at the same time, be of considerable assistance to the filling stations."

Showing on a plate the capacity of the fuel tank seems like a good idea. If, in conjunction with it, an accurate gasoline gage were provided on the car, some spilling of gasoline would be avoided and uncertainty as to how many even gallons of fuel the tank would take would disappear.

This Body Business

By R. E. Chamberlain[1]

Detroit Section Paper

ENGINEERS have been trying, ever since I can remember, to get salesmen to sell what they design, and salesmen have been trying to get engineers to design what they could sell. The difficulty has been to get Engineering and Sales close enough together in ideas so that the result would represent a product that could be sold. Many times, even though the engineer has tried to meet sales requirements, the result has been a bit curious.

When we consider This Body Business, we may say that the automotive industry has, in a sense, gone through three periods. In the first period, the most important aim was to make an automobile that would actually run; dependability was the chief requisite, and engineering efforts were directed toward obtaining it. The second was the open-body era. On course, the building of open bodies required but little engineering skill. Finally, we suddenly burst into the third or closed-body era.

When it became evident that some engineering brains was required in the body end of the business, many engineers haughtily turned a cold shoulder to the idea. Only upon the insistence of management did they give it any consideration, and then only enough to appoint some of their underlings—those whom they evidently regarded as safely passive—to the job of body engineers.

Today the situation is almost reversed. The body engineer has become all-important and his importance is growing so fast as to make it well nigh impossible for the old chassis engineers to catch up or keep pace with him.

Let me draw a contrast to prove my point. Railroad fares are identical for all roads offering service between two given points, yet one line gets the business and the other does not. Why? Because of the things involved besides the money: confidence of the passengers who ride on the road or of shippers who forward freight over it, excellence of equipment furnished, cooperation and courtesy shown by the employes, times of arrival and departure of trains, convenience of passenger and freight stations, scenic attractions and the like of the preferred road. The companies have a commodity to sell in which there is no price differential; therefore the railroad bases its bid for business on its excellence in other respects.

Again, it is very difficult to point to any outstanding advantage in any one of the leading makes of automobile tire and the difference in price is very slight; so the choice of a tire nowadays is based upon something else. The customer buys the make of his choice because of the manufacturer's reputation for excellent service, the courtesy of the company's employes, the convenient location of a service station or some other one of the elements involved, all of which are parts of true service.

Let us pause to observe a principle in merchandising. A market may be created for a cheap article like a cigarette or chewing gum by advertising but the utmost convenience is required for its vending; and if the experimental purchase is satisfactory, continued advertising, sustained quality and convenience in purchasing will continue the volume of sales until the article is surpassed by another in quality or value. You never have had a clerk try to sell you any particular brand of gum or cigarettes; he merely asks, "What kind?" Selling is as nearly mechanical as possible and the buyer requires no human contact in deciding what to buy. But when the cost of the purchase involved increases, the buyer desires to repose his confidence in an individual, and the larger the price is the more he feels that way.

While the outside of the present-day automobile is distinctly modern, its interior is, in a sense, antique, the upholstery and trim being of a style easily imagined in an old-time surrey, according to the author. The chassis engineer's dislike of body engineering has influenced manufacturers to treat the body and its appearance much as the retailer regards used cars; that is, as a difficult factor that limits business.

It seems evident, too, that public requirements have not received the attention to which they are entitled and that, consequently, the consumers are not buying automobiles as freely as they might if their ideas were given fuller consideration.

Once the functions of distribution are more definitely understood by engineers who are ready to cooperate with that end of the automobile business, the industry will be able to produce the best possible results in designing and manufacturing bodies that will meet with popular approval.

Why Bodies Dominate Sales

It is difficult today to buy an automobile that is mechanically poor. The automobile of today is a highly satisfactory piece of mechanism. Therefore the public is influenced more by the manufacturer's reputation for excellence of his product than by its own judgment

[1] General sales manager, Packard Motor Car Co., Detroit.

of the merits of the individual car from a competitive standpoint. To point to any outstanding mechanical advantages on which to base claims of superiority for any make in a given price class becomes increasingly difficult. Hence, taking mechanical excellence for granted, the public, more than ever before, is basing its decisions of purchase on other features or facts. Consequently, as good merchants, we must give thorough attention to these other matters.

Under these conditions, surely no one will discount the importance of body engineering. To say simply that it is important is not sufficient; I must go further. In what particular is it important? I doubt that it is possible to over-emphasize the importance of appearance and I am sure that a car that is excellent mechanically and offered at a fair price may easily fail to be sold if it lacks good appearance. Conversely, a car so constructed, plus excellent appearance and marketed at a fair price, may meet with great success, other things being approximately equal.

Our motor-car buyers are becoming well educated in the matter of beauty. If we would win their favor we must see that the chassis and body meet the requirements of the eye. But we cannot stop there; problems of physical comfort must be solved. People demand to ride easily, to feel comfortable through good vision and the absence of squeaks and rattles. Springs, wheelbase and shock-absorbers play their part in good riding, but so do cushion springs, upholstery, seat sizes, angularity and many other things.

Consider ventilation, regarding which the customer says, in effect: "I want to be able to use my car in Cuba and in Quebec, in summer and winter, with equal comfort and fresh air, but I do not want cold breezes blowing down the back of my neck. Oh, yes, I like to smoke in my car. You say I cannot have all those things? Perhaps not, but I am not sure; and the man who finds out how to give them to me will surely get my order."

My point is simply that body design is more important today than it ever has been, and will be still more important in the future.

Modern Outside, Antique Inside

Present-day motor-cars in no way resemble exteriorly the carriages of 50 years ago; they are distinctly modern. But it requires very little imagination to recognize in the interior that of the old-time surreys. Generally, little is new or attractive in their upholstery and trim or in its method of application. In a sense today's motor-car is modern outside but antique inside. Is there any good reason for this condition? The engineer, as a rule, likes mechanical things and is not very enthusiastic about design work of strictly body character. Perhaps not enough blending of exteriors and interiors has been done to result in a unified design of either very old or modern style. It is justifiable, perhaps, to charge both mechanical and body engineers with too little willingness to consider each other's viewpoint.

In the last analysis, it is the customer who must be pleased. The duty of our industry as a whole is to direct our energies so that we can provide him with a serviceable vehicle that has such other characteristics as he wants.

I think the fact that chassis engineers have disliked body engineering has influenced us to treat the body and the appearance elements of automobile designing much as the retail automobile merchant has regarded his used cars, the most difficult factor in the retail business. Admittedly, the used car is the principal factor that limits the selling of new cars. Not liking the used-car department, the retail merchant has not given it the attention that is necessary to handle it successfully.

In the past our car bodies have not lived up to the life of the chassis because they were not engineered sufficiently well. With style changing rapidly, the public, in an endeavor to keep up with new models and styles and to have a car the body of which does not fall apart while the chassis remains good, has traded in its automobiles when the owners had to take an excessively heavy depreciation. They naturally resist taking such a depreciation if they can avoid doing so. Hence, in an effort to secure sales volume, the automobile dealers found it necessary to allow more for these trade-in cars than they would bring in the open market and, because of changing design, were unable to sell them at prices anywhere near their real worth.

Problem of Meeting Customers' Wants

The customer is entitled to what he wants to buy, for he is the controlling factor in the transaction. The real question is, How can we give the customer what he wants and still make the product entirely dependable and serviceable? Because you, as an engineer, feel that a seat should be constructed at a certain angle does not mean that the public wants it so. Your specifying of a hard seat-cushion does not mean that Mrs. Chevy Chase enjoys riding to and from her bridge club in such a seat. Though you may judge the excellence of a car by its ability to sustain high speed, this does not mean that a purchaser will regard it favorably unless it is also quiet and easily handled at low speeds.

A very complicated problem confronts us, and I admit frankly that you will have an exceedingly difficult job and be entitled to your full quota of credit if you succeed in meeting the needs of the market. To do this, the first obvious thing to do is to find out exactly what is needed. The functions of distribution have been said to be

(1) The disposal of present-day production
(2) Market analysis, so that dealers can inform manufacturers regarding the volume and character of production that can be marketed
(3) After these are decided upon, to make the arrangements necessary for the marketing of the proposed future production.

That distribution is less efficient and has attained less perfection in this business than either engineering or manufacturing has been pointed out several times. This is admittedly true, for, compared with the engineering and manufacturing functions, the work of distribution is still unscientific. But distribution has accepted its responsibility and is developing year by year more and more scientific information upon which to base its expectations. Undoubtedly, distribution departments have often misled the engineer. I grant that they have been none too dependable and I doubt that today, without your assistance, they can fulfill satisfactorily their second requisite, namely, to fix in detail the customer's wants.

Sales departments have done things in the past

which, in all probability, have cost untold amounts of criticism and business. Yet, surely, the importance of attention to and study of this body situation is increasing relatively, from the standpoints of the convenience, comfort, and safety of the passenger. "But," I hear you say, "we have paid attention to these requisites." Of course you have, but have you considered the extent to which you will be pressed in such matters in the future? Have you given the customer the benefit of the best you can provide?

Again, quite rightly, you ask, "What can I do to assure myself of these things? How can I know what the public requires? How can I be sure when a distributor's and salesman's statements represent the combined opinion of a portion of the buying public?" Perhaps you cannot. I am sure that distribution departments are not able now to give you sufficient authentic information upon which to base safe conclusions. I believe that only by the most systematic study of the retail field and the most careful scrutiny of the tendencies of style can you arrive at safe conclusions; and then, woe be unto you if you are too far ahead or too far behind! I think it was Benjamin Franklin who said, "Never be the first to take up a new fad nor the last to drop an old one."

Principles That Will Help Solve the Problem

I hear you say, "Perhaps all these things are true and there is much to be corrected in body engineering. You have shown many faults but failed to point out the cure." That is true; but, not being an engineer, I doubt my ability to serve as your diagnostician. Certainly the problem is very complicated and I doubt if anyone will find its complete solution. But I have certain suggestions to leave with you that I believe will help:

(1) Secure a proper understanding of the importance of your work on the part of engineering, distribution and management.
(2) Promote the highest possible degree of cooperative spirit between yourselves and these departments.
(3) Submerge your own likes and dislikes and endeavor to determine as exactly as possible what is wanted by the customer.
(4) Put tradition into the background and strive for the utilitarian, the comfortable, the beautiful.

While you may not agree with me, I believe the last two of these principles will prove the most difficult. It is not easy to submerge one's own likes and dislikes. Try to reverse the order of your thought, for I would not suggest that you submerge your ideas; keep the ideas and apply them as seems wisest after determining the needs. That, too, is difficult—to determine the actual needs and to provide for them in such a way that you have a marketable product. The distribution department can and will help. But, as I do not believe you should accept the apparent facts second-hand, I suggest that you establish closer contact with the field, by more traveling and more meeting with distributors, dealers, salesmen, shop foremen, and customers; not in your office, but in their own territories and stores, where they feel at home and talk freely and where you are free of interruption by your routine. Thus we shall be able to replace, to the greatest of our ability, opinion with facts. Probably we shall not be able to meet all the needs, but at least we shall learn what the needs are and be sure that we produce the best possible result under the existing limitations.

Importance of Iron and Steel Scrap

THE GATHERING, sorting and selling of iron and steel scrap are becoming one of the substantial industries of the Country. Approximately 34,000,000 tons of scrap iron and steel, valued at more than $500,000,000, are used annually by the steel mills, blast furnaces and iron foundries. The tonnage of scrap thus utilized has more than doubled in the last decade and a half. The use of scrap iron and steel by the steel industry is economical and saves time.

The output of steel ingots for 1928 exceeded pig-iron production by over 12,000,000 tons. This spread is not only noted in United States figures, but world production offers a similar disparity. In 1919 the United States output of steel was but little more than that of pig iron. Even down to about 1925, the figures of steel and pig-iron production were much the same. It is interesting to compare the total scrap consumption of 34,000,000 tons with production figures of pig iron and steel ingots, which were respectively about 38,000,000 and 50,000,000 gross tons in 1928.

A great deal of money has been invested in machinery for such operations as baling light steel-scrap, crushing turnings, briquetting cast-iron borings, and such special operations as separating nonferrous metals from turnings by means of magnetic separators. Much material that until recently had been discarded is now being subjected to a close and scientific examination of its value as scrap. A recent statement of a large automobile company showed an income item of about $1,000,000 a year realized from the sale of its scrap materials.

The price of scrap may, and often does, reach a level at which no economy is effected through its use.

Considering the increasing amount of iron and steel in use in the world, it is evident that available scrap supplies will continue to mount and will grow in importance.

The main contributors to the scrap pile are, as a rule, the iron and steel producers themselves. The railroads are very important sources of the materials, as are also industrial concerns, automotive factories, the construction industry, and ships destined to be broken up. To assure a satisfactory return for their efforts in the collecting and selling of scrap, dealers sort the material as it comes in and classify it by grades and sizes.

Sharply fluctuating price-levels, along with various trade problems and unethical practices in the industry, were instrumental in bringing about the formation recently of the Institute of Scrap Iron and Steel. The growing importance of the business necessitated some central organization in which its various problems could be studied, statistics gathered and other services performed tending to elevate and stabilize the industry. The program of the Institute is substantial in scope. It is hoped to eliminate unfair practices on the part of both the dealer and the mill owner so that the seller may obtain a fair profit yet guarantee the buyer that he will receive exactly what was ordered.—*Commerce Monthly.*

The Development of Fixed Radial Air-Cooled Engines

By GEORGE J. MEAD[1]

MILWAUKEE SECTION PAPER — *Illustrated with* PHOTOGRAPHS

COMPARISON by the author shows that the cost of aeronautic powerplants per horsepower is materially lower than that of ship powerplants, and that airplane reliability compares well with the safety of other modes of travel. Some of the advantages of radial air-cooled aeronautic engines are given, followed by a brief outline of their development, which was necessarily slow because of the novel mechanical problems involved in the connecting-rods, valve mechanism and lubrication.

The supercharger drive and the recently developed propeller reduction-gears of the Wasp engine are described, and the paper concludes with an outline of procedure in developing a new model of engine.

In the absence of Mr. Mead, the paper was presented by E. A. Rider, who answered the many questions propounded in the discussion. These have to do chiefly with supercharging, cooling problems, engine operation in flying upside down, and the use of a double ignition system.

TO THE AVERAGE person, the aeronautical powerplant is still light and flimsy. Facts, however, show that a modern airplane and engine, with an experienced pilot, operated over an established airway, are really safe when compared with the standards set by other means of transportation. A great deal has been accomplished since the war. In 1917 the best powerplants would operate only about 10 hr. at full throttle without overhaul and weighed from 2 to 3 lb. per hp. At that time an airplane speed of 110 to 115 m.p.h. was considered good. In contrast with these figures, the modern radial engine runs from 30,000 to 50,000 miles between overhauls and weighs between 1½ and 1¾ lb. per hp. The fuel consumption averages from 5 to 8 miles per gal., while the speed of the airplane has been tremendously increased. It is interesting to compare the approximate average figures for cost and performance with similar figures for other prime movers, as has been done in Table 1.

The percentage of power used has a direct bearing on the frequency of overhaul. It is not possible to provide an ample surplus of power in water-cooled powerplants, as it costs too much in weight, but surplus power can be provided in air-cooled engines with the addition of very little weight. This permits operation at part throttle, at the same time providing a reserve for the maintenance of schedule in spite of bad weather conditions.

The modern aircraft powerplant has been obtained by evolution. Air-cooling was tried by the pioneers in aviation on account of the weight saving, but the initial attempts failed because of lack of experience. In 1909, though, Bleriot crossed the English Channel with an Anzani three-cylinder radial air-cooled engine which was virtually a two-cylinder V motorcycle-engine with a third cylinder added. Owing to the difficulties of cooling the fixed radial engine of that period, rotary engines were developed to provide the additional cooling which was necessary in the slow-speed airplanes, at a time when 35 to 40 m.p.h. was regarded as high speed.

The French entered the war in 1914 with rotary engines. As the demands for power increased, water-cooled V engines took their places. The British, however, were convinced of the superiority in airplane performance to be obtained with air-cooled engines and therefore carried on extensive experiments, with the result that they expected to use air-cooled engines exclusively in 1919. The post-war development of the air-cooled engine was slow, mainly because of the large surplus of military aviation equipment.

Gnome and Le Rhone rotary engines were built in this Country during the war, and Charles L. Lawrance built a two-cylinder opposed and a three-cylinder radial engine of 60 hp. The Army was anxious to determine the advantages of air-cooling and consequently held a design competition in 1919 for a 350-hp. radial engine. This was the beginning of military interest in the air-cooled radial engine in this Country. Soon afterward the Navy, in view of the space restrictions imposed by the airplane carriers as well as to improve the performance of the airplanes, encouraged the development of a smaller nine-cylinder radial of approximately 200 hp.

TABLE 1—COMPARATIVE APPROXIMATE DATA FOR SEVERAL PRIME-MOVERS

	Pounds per Horsepower	Cost per Horsepower	Thermal Efficiency, Per Cent	Percentage of Power Used	Miles per Overhaul
Locomotive and Tender	114	$20	..	38	100,000
Steamship Powerplant	450	135	..	75–80	30,000
Diesel Ship Powerplant	475	145	30	75–80	30,000
Aircraft Powerplant	1.75	18	29	75–80	30,000 to 50,000
Automobile Powerplant	8	..	13	15	10,000

[1] M.S.A.E.—Vice-president, Pratt & Whitney Aircraft Co., Hartford, Conn.

The first of these engines was built by Mr. Lawrance and later engines by the Wright Aeronautical Corp. Once this type was thoroughly developed, the Navy became interested in a larger size of approximately 400 hp. The Pratt & Whitney Wasp engine was designed to meet this demand. No sooner had this been put in production than a larger size was required by both the Army and the Navy, and we now have two 525-hp. engines, the Wright Cyclone and the Pratt & Whitney Hornet.

Why Air-Cooling and the Radial Type?

The first reason for the air-cooled engine is additional safety on account of the elimination of the water-cooling system. A large percentage of the forced landings with water-cooled engines have been due to the plumbing. In addition to this, the saving of about 25 per cent in the weight of the powerplant is important to the commercial operator, since each pound saved can be replaced by a pound of pay-load. Another important consideration is the amount of reserve power available with very little additional weight.

The first reason for the radial disposition of the cylinders is to obtain uniform cooling, which in turn makes possible maximum power with minimum fuel-consumption for that power. With any other cylinder arrangement, uniform cooling is difficult; and it is often necessary to turn the stream of cooling air at right angles, which absorbs power. Also, the radial form attains the lowest weight per horsepower of any known type, and both its first cost and maintenance cost are low. For these reasons it is probable that the radial engine will hold its own for a long time to come, within its power limitations.

The principal reason that this form of engine was not developed earlier was lack of experience and of certain materials. Air-cooling has been adopted as fast as our experience would allow. Cast iron was used for the cylinders of the original engines; later, steel of a very thin section. Progress would have been much faster if more material had been put into the cylinders, as we have since learned to do. Despite the additional weight, the power output is more than proportionately greater. It is necessary to use ample cross-sections of materials that have such poor heat conductivity. Aluminum was first introduced for cylinder construction about 10 years ago, and progress has been more rapid since. After all, the cylinder problem is mainly one of eliminating hot-spots and disposing of excess heat. This is ideally accomplished by thick sections of light alloy having high conductivity.

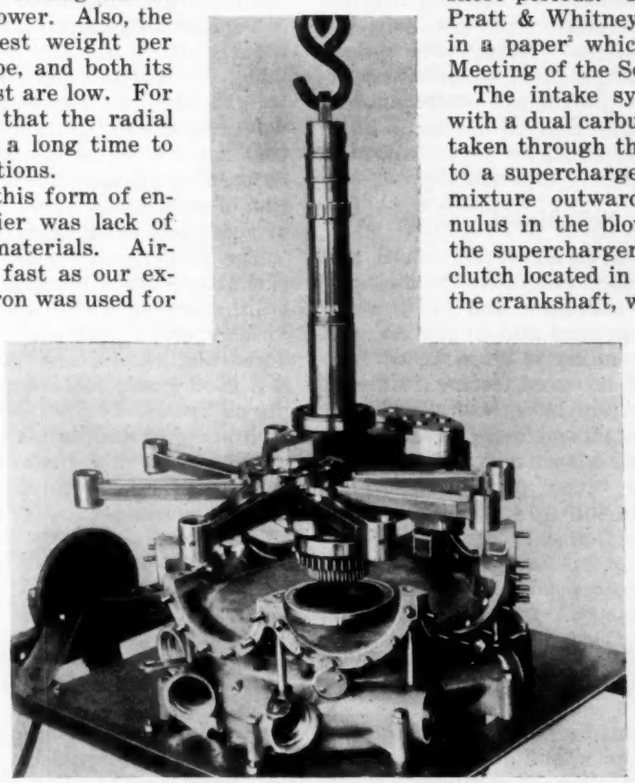

FIG. 1—LOWERING THE CRANKSHAFT ASSEMBLY INTO PLACE IN ASSEMBLING A PRATT & WHITNEY AIRCRAFT ENGINE

Very considerable metallurgical progress has been made in materials for valves and valve-seats. In the evolution, we have gone from cast iron to carbon steel, thence to tungsten steel, followed by chromium and finally by nickel-chromium alloys. In the same way valve-seat material has changed from cast iron to steel and then to various aluminum bronzes.

The special mechanical problems of the radial engine are novel—particularly those concerning the connecting-rod design, valve mechanism and fuel distribution, for which there were no engineering precedents—so that progress has been retarded until each particular feature was tried out. Some of these problems are visualized by Fig. 1, which shows the assembly of a built-up crankshaft with connecting-rods being lowered into place in the blower section of the engine. The pioneers in the industry have established whatever standards now exist, and have thus made it comparatively easy to duplicate some of their efforts.

Modern aircraft powerplants are simple, compact and durable. An example is the 450-hp. Wasp, which is a nine-cylinder fixed radial engine, with the valve mechanism enclosed and all the accessories located at the rear. This engine weighs approximately 1½ lb. per hp. and develops 130 lb. per sq. in. m.e.p. without supercharging. Its normal operating speed is 2100 r.p.m., and it is capable of speeds as high as 2800 r.p.m. for short periods. Descriptions of this and the Pratt & Whitney Hornet engine were given in a paper[2] which I read at the Aeronautic Meeting of the Society in 1926.

The intake system of the engine begins with a dual carbureter, from which the gas is taken through the rear section of the engine to a supercharger impeller which forces the mixture outward through vanes to an annulus in the blower section. The drive for the supercharger is taken through a friction clutch located in the spur gear at the rear of the crankshaft, which takes care of the accelerating and decelerating forces that would otherwise impose severe strains on the drive. The drive is through a countershaft located below the drive gear and back to the impeller shaft, which is concentric with the crankshaft. For normal service, the impeller is driven at seven times engine speed, or approximately 15,000 r.p.m. In some installations a hot-spot is inserted between the carbureter and the impeller; in others, hot air is supplied to the intake of the carbureter from the exhaust collector-ring. Much trouble has been experienced from ice forming in the carbureter, and a considerable amount of heat is necessary at certain seasons of the year to prevent this difficulty.

This engine is furnished with propeller reduction-gearing, shown in Fig. 2, as well as direct drive. The

[2] See THE JOURNAL, December, 1926, p. 609.

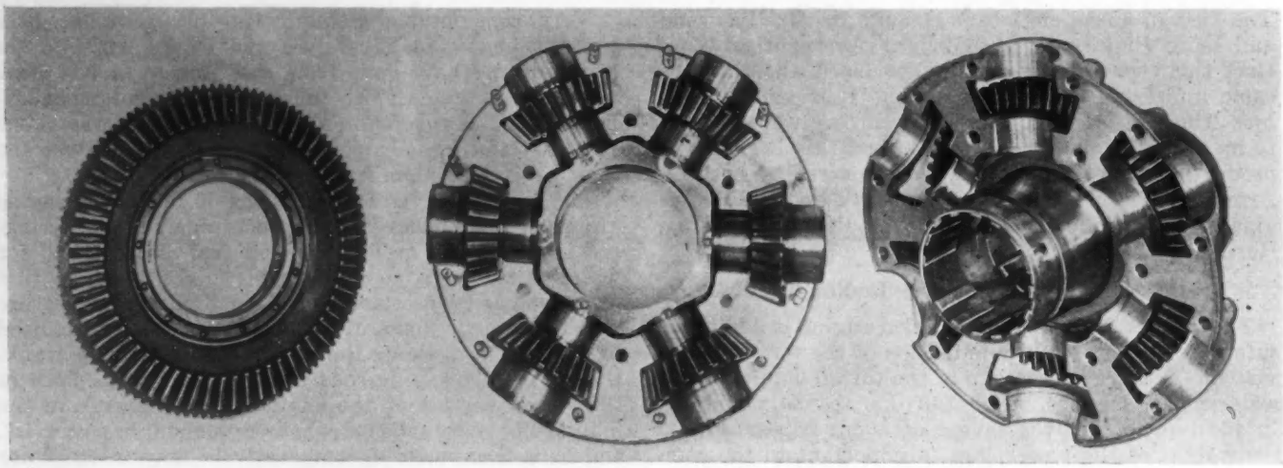

FIG. 2—PROPELLER REDUCTION-GEAR FOR PRATT & WHITNEY HORNET ENGINE

Six Pinions Roll Between a Fixed Bevel-Gear and a Similar Gear Mounted on the Crankshaft. Links Connecting the Inner Ends of the Pinion Shafts Serve To Equalize the Tooth Pressures. The 2-1 Reduction Is Secured by Connecting the Propeller to the Pinion Carrier

gear, which provides a 2-1 reduction between the engine and the propeller, comprises six bevel pinions which roll between a ring gear on the crankshaft and a fixed ring-gear attached to the crankcase and thus rotate the carrier in which they are mounted at one-half engine-speed. The carrier is connected with the propeller through an internal-external-gear clutch. The unique feature of this device is the patented equalization arrangement, by which all the pinions are interconnected through linkage in such a way that their load is automatically equalized. The gear assembly weighs approximately 40 lb. and has proved very dependable.

Developing a New Model

The development and construction of a modern aircraft engine requires a degree of perfection beyond that of almost any other line of endeavor, and involves extensive testing both on the ground and in the air. In our case, a single-cylinder engine is constructed first and put through hundreds of hours of testing. After a satisfactory cylinder and piston have been developed, a complete engine is fabricated and tests begun on it. When its development reaches a satisfactory stage, the engine is subjected to a 50-hr. "type" test, during which it is run at normal speed and full throttle. No repairs are allowed to be made during the test, and the engine parts must be in good condition afterward. Following the type test, development engines are installed in airplanes and operated under varying conditions before production starts on the new type.

Considerable actual experience is required to produce a satisfactory airplane powerplant, because of the unusual conditions under which it operates and the low weight required per horsepower. A good engine involves so much operating experience and shop know-how that it is far better to continue with its evolution as far as possible than to change to a new type. This evolution of a basically sound design can go on for a number of years before its possibilities are exhausted.

The modern air-cooled radial engine is a very dependable piece of mechanism, provided it is carefully built, operated under suitable conditions, and serviced by competent personnel. Operating costs will be reduced and greater service rendered by the powerplants if a good grade of antiknock fuel and suitable lubricating oil are used. Sufficient power should be provided in each plane to maintain the required schedule in normal weather with 75 per cent of the engine's maximum output. The industry must guard against too rapid expansion, as money cannot take the place of experience.

THE DISCUSSION

ELLING O. WEEKS[3]:—What experience are you having with air-cleaners such as are used on carbureters in the South where there is dust?

E. A. RYDER[4]:—We have tested a number of air-cleaners but have come to no conclusion and are still working on the problem. Most of the cleaners available are so large that it is hard to find room for them. They have to handle about 1000 cu. ft. of air per minute, and the cleaners which consist merely of vanes that give the air a twist do not take out the fine dust.

F. M. YOUNG[5]:—Have you tried passing the air through gauze? Have you tried taking air from different points? It would be bad to take the air from the top of the cowl because of rain, but it seems as though it would be better to take it from some place away from the dirt that is raised by the propeller.

MR. RYDER:—Air has been taken from the top in some of our installations, and it seems to work out very well. The rain does not make much trouble; most of it will drain out at the bottom, on the principle of an air-cleaner.

E. L. MONSON[6]:—What are the compression ratios of

[3] Weeks Aircraft Corp., Milwaukee.

[4] Assistant engineer, Pratt & Whitney Aircraft Co., Hartford, Conn.

[5] M.S.A.E.—President, Young Radiator Co., Racine, Wis.

[6] Assistant engineer in charge of development, Nash Motors Co., Milwaukee.

the Wasp and Hornet engines, and what is the lowest grade of fuel that can be used?

MR. RYDER:—The compression ratio of the Wasp engine is 5¼ to 1 and that of the Hornet is 5 to 1. These engines will not run at full throttle with automobile gasoline. We use what is known as domestic aviation gasoline, which has a specific gravity of 66 to 68 deg. Baumé, or lighter. Ethyl fluid is needed with the 66-deg. gasoline in many cases, but the engine will run very nicely on 73 to 76-deg. naphtha.

H. L. ZIMMERMAN[7]:—Is it necessary to provide some of the pistons with greater cylinder-bearing surface than others, on account of the difference in angle between the various connecting-rods? In which cylinder is the connecting-rod angularity greatest?

MR. RYDER:—I believe that the angularity is greatest in cylinders Nos. 4 and 7 of a nine-cylinder engine, but we do not observe any effect from the difference in side-thrust. The positions of the articulated-rod joints are adjusted so that the stroke is the same in all cylinders, within a very small amount.

A. BARTLETT[8]:—Is there any tendency for the lubricating oil to settle in the lower pistons? How is the oil drained away from the crankcase?

MR. RYDER:—The cylinders project into the crankcase about 2 in., and the oil is drained away from the space between them. There is no difference in lubrication between the upper and lower cylinders.

R. SCHAEFER[9]:—How is the starter connected with the engine?

MR. RYDER:—By a clutch on the low-speed shaft, next to the starter jaw, that slips momentarily when the starter is engaged. It is adjusted to limit the load that can be placed on the jaws and slips in case of a backfire. It also slips a very little when the jaws are first engaged.

Various Degrees of Supercharging Available

W. F. KRENZKE[10]:—What degree of supercharging is used? Can it be changed during flight?

MR. RYDER:—The supercharger cannot be changed during flight, as the change requires putting in different gears. As ordinarily furnished for commercial use, the pressure in the inlet pipe is between atmospheric and ½ lb. per sq. in.; but it is possible to obtain 3 lb. per sq. in. or more by changing the gear ratio. Ordinarily it is not possible to supercharge more than enough to maintain sea-level power at 12,000-ft. altitude without a cooler between the supercharger and the cylinders. The air expands so much at the higher temperature that the effect of increased pressure is neutralized and the weight of a cylinder-full of air is not increased. Single-stage supercharging is quite all right for moderate amounts, enough to maintain sea-level power at 5000 to 8000-ft. altitude.

C. W. PENDOCK[11]:—Do you use salt-cooled valves? What is the highest mean effective pressure that you have found practical in the Wasp engine?

MR. RYDER:—We do not use salt-cooled valves. The exhaust-valve stem is hollow, to provide more surface for heat transfer to the valve-guide, but the hole contains nothing but air. The engine develops about 130 lb. per sq. in. m.e.p. without supercharging. In a high-speed airplane, where the cooling conditions are good, the engine will stand supercharging enough to give about 150 or 160 lb. per sq. in. in m.e.p., but that requires special fuel.

A MEMBER:—What do you consider the highest safe operating temperature of the exhaust valve? Can the same cooling effect be secured with deeper fins having heavier bases as with the short, thin fins?

MR. RYDER:—I do not know at what temperature the exhaust valves run, but they are red-hot.

The conductivity of steel is rather poor, and therefore the weight efficiency of a high fin is rather poor. The lower the fins are, the more cooling can be obtained per pound of material, up to the point where the fins are close enough together to interfere with good air-circulation. Aluminum fins can be much deeper on account of their better conductivity.

A MEMBER:—I have had better results, in the cast-iron cylinders for a very small air-cooled engine, with fins that are heavy at the base and deep. If the fin is thin, it seems to do no good to make it very deep. Many small air-cooled engines will stop after running about 30 min., and the improvement is very great with deep, heavy fins. Of course, the conditions are quite different with steel and aluminum.

L. A. DOERNER[12]:—What is the thickness of the material between the fins in the head?

MR. RYDER:—About 7/16 in.

H. L. DEBBINK[13]:—What is the temperature of the aluminum-alloy cylinder-heads when they are shrunk onto the cylinder-barrels, and how hot do the heads become in ordinary service?

MR. RYDER:—The heads are shrunk on at about 500 deg. fahr. Subsequently they are painted, the enamel being baked on at about 425 deg. The part of the head surrounding the barrel does not get hot enough to reduce its strength in service. Parts of the head around the exhaust ports rarely become hot enough to burn off the paint, which requires a temperature of about 600 deg. When it occurs, this temperature is only local and does not affect the working of the engine because it does not extend to the combustion-chamber.

Adjusting for Fuel Economy

A MEMBER:—What is the fuel consumption per horsepower at three-quarters load?

MR. RYDER:—The guaranteed fuel consumption is 0.55 lb. per hp-hr. The carbureters are equipped with an altitude mixture-adjustment which enables the pilot to make the mixture leaner as it tends to become richer at higher altitudes. The ordinary setting of the carbureter is such that the fuel consumption would be about 0.6 lb. per hp-hr. at full throttle with the mixture control in the full-rich position. Throttled to about 1800 r.p.m., as it would be at ordinary cruising speed, the engine will develop about 70 per cent of full power with a fuel consumption of 0.55 lb. per hp-hr., or a little less, on the full-rich setting. The pilot can lean out the mixture as much as the conditions will allow. Ordinarily, the engine will run at half throttle with about 0.52 lb. per hp-hr. and will run on less than 0.50 lb. if the adjustment can be made nicely enough.

In the air it is hard to determine when the optimum

[7] A.S.A.E.—Assistant engineer, Nash Motors Co., Milwaukee.
[8] Chief engineer, Le Roi Co., Milwaukee.
[9] Waukesha Motor Co., Waukesha, Wis.
[10] M.S.A.E.—Chief engineer, Jacobsen Manufacturers Co., Racine, Wis.
[11] President, Le Roi Co., Milwaukee.
[12] Chief designer, Harley-Davidson Motor Co., Milwaukee.
[13] M.S.A.E.—Superintendent of gasoline vehicles, Milwaukee Electric Railway & Light Co., Milwaukee.

mixture is obtained, which is not the leanest mixture on which the engine will run. The best we have been able to do is to determine in the laboratory the difference between the engine speeds with the mixtures for the best power and the best economy with the same throttle-setting. With this information, the pilot can adjust the mixture control to give the highest speed, then lean out the mixture until the engine speed has dropped 40 or 50 r.p.m. The adjustment will then be very close to the point of best economy.

L. L. BOWER[11]:—How is the fuel supplied to the engine when flying in the inverted position?

MR. RYDER:—We do not equip the engines so they will operate upside down; that is done by the airplane builders. The simplest way to arrange that is to provide a jet in the fuel line which will pass about the amount of fuel that the engine needs at full throttle, with extra fuel tanks or some other provision for a supply of fuel in any position. With some such arrangement, the engine will run upside down long enough for the airplane to go through some very pretty evolutions. The crankcase tends to become filled with oil, because the drain connection is at the top when the engine is inverted, so continuous flight in the inverted position is not possible.

MR. MONSON:—What consideration led you to adopt twin ignition?

MR. RYDER:—We use it for reliability. The engine will run perfectly well on one set of spark-plugs, although at a slight loss of power. Why is twin ignition used on the Nash car?

Double Ignition in a Car Engine

MR. MONSON:—We began experimenting with twin ignition in 1922, with the idea of burning the charge completely to avoid carbon deposition. The experimental four-cylinder Nash car which we built with twin ignition in 1922 is being operated now by a groceryman in South Milwaukee, who claims to have driven it 80,000 miles without removing the carbon.

When we began the development of the 400 Series, Nash special-six engine, with 3¼ x 4½-in. cylinders, it had cast-iron pistons and a compression ratio of 4½ to 1 and developed 53.5 hp. at 2600 r.p.m. We were obliged to increase the power of the engine because of increased weight of the car and the demand for better performance. We increased the compression ratio to 4.7 to 1, and the engine developed 55 hp. at 2600 r.p.m. A car with this engine could be driven, and it drove fairly well in the neighborhood of Denver, but it was not satisfactory at ordinary levels because of detonation. Next we tried aluminum pistons and 5-1 compression. The engine then delivered 59 hp. at 2600 r.p.m., but it could not be driven; it "pinged" at from 3 to 55 m.p.h.

As we were limited to a cylindrical form of combustion-chamber, with valves in the head, we could not adopt the expedients that are used in L-head engines to allow high compression, so we began to experiment again with twin ignition. We built the first model of the final design in October, 1928. This engine has 5.15-1 compression with a single cylinder-head gasket, and 5-1 compression with two gaskets. We took it to Uniontown Hill in Pennsylvania, and found that we could drive it without detonation or "pinging" with the 5.15-1 compression, which is our present ratio. The engine develops 65 hp. at 2800 r.p.m., and the fuel economy was improved about 2 miles per gal. Our present four-door sedan weighs about 240 lb. more than the corresponding previous model and out-performs it by 15 per cent. This engine does not require non-detonating fuel.

[11] Installation engineer, Waukesha Motor Co., Waukesha, Wis.

International Air Traffic

WHILE, in the development of the international air-transportation system, it is most necessary to perfect the mechanical equipment, such as airplanes, landing-fields and radio communications, it is equally essential that the rules and regulations governing the operation of the aircraft, and in particular those governing the entry and clearance of aircraft between countries, should be framed with special attention to the necessity for simplicity and speed. It has been the experience of some air-transport companies in the past that the time saved by rapid transportation through the air was lost in the execution of formalities on the ground.

The problem is now becoming more clearly understood, and the progress toward a unified system of the greatest possible simplicity is most gratifying. As an example, the rules and regulations governing air transportation between Canada and the United States are well understood and simple in form and method.

The problem has been met and solved in European countries in a similar manner but, as the time is rapidly approaching when the air-transportattion network of the world will be connected unit to unit, it is essential that every effort be made to extend the work of simplification of operating procedure and of governmental requirements.

In the western hemisphere the problem of international air transportation requires that immediate and serious consideration be given to the establishing and modifying of rules for governing it. Fortunately, governmental agencies and international agreements are already in existence which, if properly utilized, will provide a means for the establishment of rules favorable to international air transportation that will mean development of international traffic that will result in a corresponding increase of commerce and a better understanding between the countries thus connected.—From an address by R. F. Hoyt at the International Civil Aeronautics Conference.

Architectural Treatment of Airports

By Francis Keally[1]

Metropolitan Section Paper — *Illustrated with* Drawings

AVIATION is the great transportation method of the future, and we must look at it in a big way to avoid mistakes in the planning of airports. The great airport at Croydon, England, for example, was completely rebuilt a year ago at an expenditure of $1,000,000; and I understand that the obsolete buildings, all of which were razed, originally cost $600,000. So we are endeavoring to promote the idea of planning airports intelligently, with expert advice. Certainly we do not want to follow in the steps of the early railroads. Since Colonel Lindbergh landed at Le Bourget, $300,000,000 has been spent in this Country on airports by more than 1000 communities, and it is probable that an additional $200,000,000 will be spent by another 1000 communities during the next year.

Our tourists undoubtedly will make their trips by airplane, not only for the better view they will be able to get of the country from the domain of the eagle, but also because they will be able to cover a much larger territory in a given time. I can well imagine there will be airports some day on Pike's Peak and other lofty mountain tops. Nor is there any logical reason why airports cannot be built in the neighborhood of great canyons, so that tourists can get the greatest variety of scenery.

Just as modern architecture and design now are building up an American art which best expresses the kind of civilization in which we live, so will the architects and engineers of our airports take into consideration the surroundings in which the airports will be constructed. There is no reason for having a black airport on Pike's Peak, for instance, where the underlying color scheme is wind-driven snow. Nor should an airport built in the desert resemble a kaleidoscope; rather, its coloring should resemble the sand and the cactus of the desert in which it is built.

Commuting to the big cities by airplane from anywhere within a radius of 200 miles is envisioned by Mr. Keally as within the probabilities of the next few years. Centrally located landing-fields will be needed for commuters and business travelers, who should find small airplane taxis available at the large airports. Airport planners should avoid the constricted locations of early railroad stations and the ugliness of early garages. Buildings should be planned so that they will not need to be torn down to provide for expansion, and beauty inspires confidence.

Parks and amusement facilities in the immediate neighborhood of an airport are asserted to be desirable. A circular design, in which all the buildings are in the center, is mentioned.

The discussion emphasizes the need of hard-surfaced fields, since dirt fields are either dusty or muddy. Mention is made of the tendency for airplanes to require more airport room, and of the opposed possibility of improvements in aircraft making larger fields unnecessary. Proposals for safety with increased traffic include separate landing and taking-off fields and the division of the field by an imaginary line parallel to the wind, all incoming planes to land on one side and all departing planes to take off on the other side of this line. Either plan would permit several airplanes to land and take off simultaneously without collisions.

Central Landing Places

Airports for business men who are in a hurry will be situated close to the business and hotel districts of the great centers of population, so that little time will be lost in going from them to the outlying terminal airport. Suburban airports will be located 100 to 200 miles from great centers like New York City, as commuting distances will increase because of the speed of the airplane. In short, the airplane will make great distances seem smaller than the present small distances. Farms and virgin country within a radius of say 200 miles of great cities will thus become developed to a high degree by the airplane, in the same way that towns near the larger centers of business have been developed by the railroad and the motor-car.

A system of air taxis probably will be developed. It would be impracticable to land a large transport plane, carrying from 10 to 25 passengers, atop a wharf or upon the roof of a great railroad terminal in the heart of a city. Manifestly, such a heavy plane would have to land at one of the big terminal airports. But there is no reason why transportation should then revert to the present automobile taxi. How much simpler to transfer from a large airplane to a small one, and travel through the air the 10 miles or so that separate the terminal airport from the heart of the city. A small plane could easily land on top of a wharf or building, just as it can on the deck of an airplane carrier.

Many architects have even suggested that landing-stages be built above the wharves, unobstructed waterfront streets or railroad switching yards of cities, each affording space for landing a small plane with passen-

[1] Architect; lecturer in the School of Architecture, Columbia University, New York City.

gers from the terminal airport. Such a landing-stage, proposed for erection over the wharves at West and 14th Streets, New York City, is pictured in Fig. 1.

As it is very important to expedite air-mail from large airports in the suburbs into the city, it is suggested that the landing platforms over piers or wharves be equipped with pneumatic mail-tubes. It would then be possible for a letter posted in Boston at 11 a.m. to be received by the addressee in New York City the same day at 3 p.m. Assistant Postmaster General Irving Glover recently told the Congressional Airport Commission for the District of Columbia that the day is not far distant when post offices will be connected with the more important airports by pneumatic tubes.

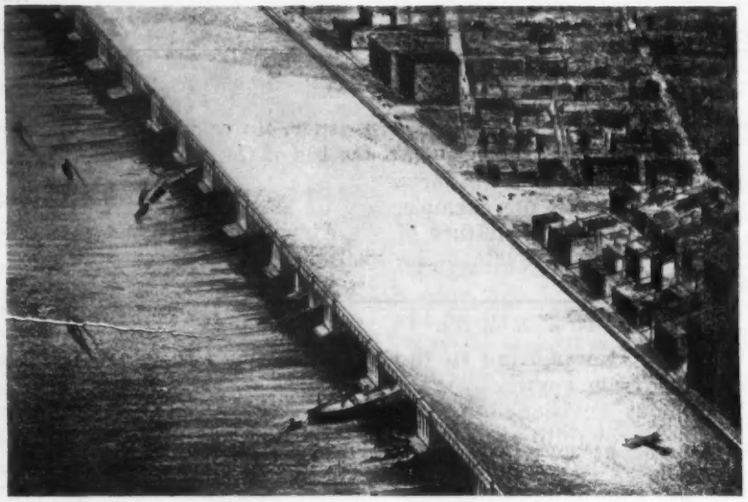

FIG. 1—SUGGESTED LANDING PLATFORM OVER NEW YORK CITY DOCKS

Starting with an Airplane Photograph of Lower Manhattan Island, the Author Has Prepared This Sketch Showing How a Landing Platform Could Be Built at West and 14th Streets. The Proportions Can Be Judged by Reference to the Ocean Liners Shown Emerging from the Docks. The Surface of the Platform Would Be Made with Grating, Through Which Snow and Rain Would Fall

Few realize how wonderfully efficient pneumatic tubes are for carrying mail. In New York City alone they average more than 140,000 container-miles daily, equal to a journey of 5 2/3 times around the world. This system for the swift transfer of mail under the streets of the city should be connected with the system for swift transfer of mail by airplane to and from distant points. It is possible that post offices will be established at the airports with pneumatic tubes for transmitting mail direct to the large office buildings without going through the main post offices.

Plan for Expansion

After utility has been provided for, it is most important that airports not only be made beautiful but that they be planned so as to provide for expansion of at least 100 per cent, and even more near large cities where, like railroad terminals, it will be economical to have as many air-lines as possible converge at one terminal.

Vitruvius, the great historian, once said that utility, stability and beauty are the three prime factors in a building that is to last and live; in the building of airports we are today in the stage in which the building of garages found itself 15 years ago. The automobile came upon us suddenly and had to be housed quickly; people simply had to build sheet-metal garages in their back yards or in corners of vacant lots, or have no roof for their cars. But now the suburbs of any large city have some very beautiful garages that have been incorporated in the landscaping scheme. Why can we not solve our hangar problem now in a way that will satisfy both our utilitarian needs and our desire for beauty, without waiting 15 years?

The airport should be part of the city plan, and every city-planning commission should take the airport into consideration. Even in China, experts are being employed to lay out airports; for the Chinese find the airplane the cheapest method of transportation, because it is unnecessary to build roads and to tunnel through vast mountains.

The Lehigh Airports Competition, which I have the honor to serve as professional adviser, has been inaugurated to stimulate the building of airports that will be more beautiful and, at the same time, most practical. This competition, which is sponsored by the Lehigh Portland Cement Co. as a gesture of goodwill toward the world's newest transportation system, is for a prize of $10,000.

Among the facilities which the airport of tomorrow will have, and which the airport of today should have had, are hangars; parking spaces for planes and automobiles; a hotel; a terminal building, with ticket offices, waiting-rooms for incoming and outgoing passengers; shops; and concessions. An airport news-stand should be able to sell today's newspapers from cities within a 1000-mile radius, and the fashion shops should be able to show the latest styles from the Paris boats. As surely as aviation will develop into one of the most important factors of our civilization, so surely will the airport concentrate all the activities of a community within its boundaries.

If aviation is to develop to its full stature, it must have the best and most modern terminals that can be built. What is really needed, and already has gotten well under way at Tempelhof and at Croydon, is to bespeak the cooperation of the architect, the engineer and the city planner. Manifestly, the modern airport should be comparable with the modern railroad terminal. This does not mean that American communities, beleaguered on all sides with financial commitments of various kinds, should take time by the forelock and construct an airport today that will be able to handle the air traffic of 2000 A.D. It does mean that whatever expenditure is made today should be a sane expenditure. The money should be invested in a modest airport, built with imagination and with an eye to the future, so that expansion will be a simple process of addition and the original investment will not need to be scrapped when aviation reaches the crest of its development.

Dignity Promotes Confidence in Aviation

The airport must have an atmosphere of dignity and permanence, to create confidence in aviation. This can

be accomplished through beauty as well as through orderliness of technical procedure. We must not forget that it will be exposed to the critical view of the man in the sky. We may or may not adopt the method of Andre Le Notre, the architect who laid out the grand plan of the palaces and gardens for Versailles. He put colored pebbles on the ground, thus giving the ground the sky-view effect of a garden. We may put colored pebbles on the roof, to hide the ugliness inherent in bareness; and, whatever we do, we must combine beauty with utility, or an aroused citizenry will rebel at the grotesqueries which were thought to have been discarded years ago.

I believe that an airport can be made a real civic center for recreation and entertainment, as well as a place for the business of flying. A park system, athletic fields, swimming pools, boating, dance halls, indoor and outdoor restaurants, a hotel and a model community should be developed, with good transportation facilities and parking spaces for airplanes and automobiles.

E. P. Goodrich and I have been working on plans for a circular airport, 7500 ft. in diameter, with all the buildings in the center. With runways 350 ft. wide, 22 airplanes can be landed simultaneously and stop at the buildings, and 22 airplanes can take off at the same time. Fig. 2 is a sketch of this field.

I believe that all large cities and many towns of secondary importance will require landing-fields within 5 or 10 years, just as they now require railroad stations. The landing-field, because of its area and the traffic it will draw, will become one of the major features of the community. Its activities may become so important that an entire community will develop around it; and it will be necessary to think of the airport as the hub, with the transit facilities as the spokes of the wheel, and with homes built around the periphery.

Now is the time for planning, to avoid the helter-skelter way in which the problems of rail and water transportation were met by our fathers and grandfathers.

THE DISCUSSION

A. E. JOHNSON[2]:—The most deplorable fact about the airports throughout the Country is that the ground is either dry and dusty or wet and muddy. The remedy is to have hard fields, or at least hard runways. At our Dayton airport we have Tarvia runways; but many of the pilots prefer to land on the grass, and the grass will not last long under those conditions. The ground cannot be kept in good condition where it is sometimes covered with snow and is subject to freezing and thawing. Entire fields will be hard-surfaced in the future, except for strips of grass for architectural beauty and for landing without brakes.

Air-mail planes have been subject to many delays this

[2] Johnson Airplane & Supply Co., Dayton, Ohio.

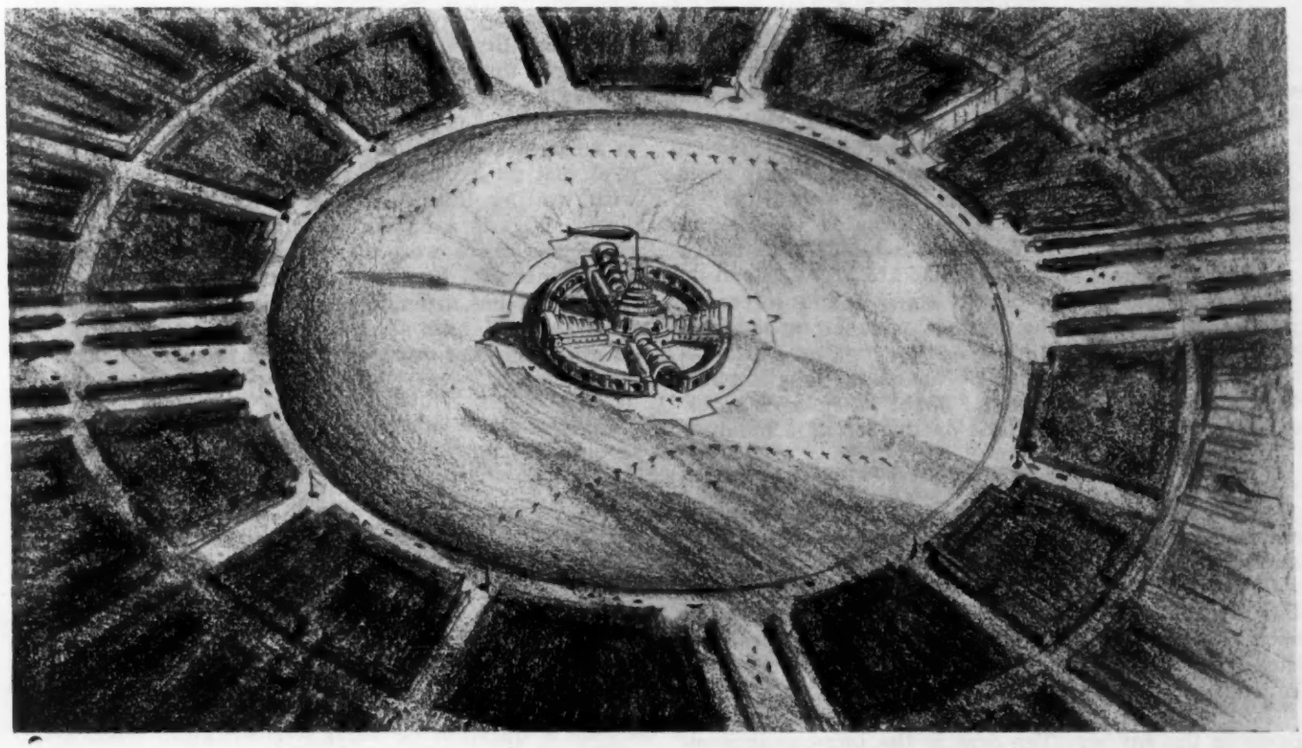

FIG. 2—THE PROPOSED BEE-HIVE TYPE OF AIRPORT

This Port Is Intended To Be 7500 Ft. in Diameter, with the Buildings in the Center. More than 20 Airplanes Can Take Off Simultaneously, Starting Their Run into the Wind from the Buildings; and an Equal Number Can Land at the Same Time, Finishing Their Run at the Center of the Field. Included in the Plan Is the Proposal that Regulations Shall Restrict the Height of Surrounding Buildings so They Will Not Interfere with the 7-Per Cent Glide of an Airplane Approaching the Margin

spring because of muddy fields, and a number of them have had propellers broken because of nosing over in landing on soft ground. They could not take off at all from certain fields because of the soft ground. As airplanes are growing larger and heavier, it is more important that the landing-fields should have hard surfaces. Grass fields could be kept in good condition a few years ago, when they were used by only a few planes; but conditions are different now, and brakes and wheel tail-skids give much better control on the ground.

At an Army air-field airplanes will sometimes be seen taking off or landing a dozen at a time. This can be done because the flying is well organized; but it cannot be done without danger of a tangle at a field where there are commercial fliers from various cities. We are suggesting to the Department of Commerce that each field have an imaginary dividing line, in the direction of the wind, all pilots to keep to the right of this line in landing and to the left in taking off. This would avoid confusion and make it safe for a number of airplanes to be taking off and landing at the same time.

At most airports it seems to be believed that the "hot dog" and hamburger sandwich are all the food that an air traveler needs or can expect. We have found at our airport at Dayton that people will patronize a first-class restaurant. From 500 to 3000 visitors come to the port every night. They are interested in seeing the 8:50 mail-plane come in from Louisville. They can see the lights of the plane in the distance, and the pilot usually gives them a zoom before he lands. These visitors got tired of "hot dogs" and pop, so we started to feed them a little better; and they like it. If we had the money to invest in swimming pools, skating rinks and tennis courts, I believe they would pay.

We find it absolutely necessary to have field men at an airport at all times, to keep the field in order and to see that everything like wheel-chocks is cleared away and that warning flags are put up in soft spots. We have these men in uniform, for identification, and their information service is appreciated by visitors. We have also found it very useful to install a microphone to announce the planes that are arriving and departing; it keeps the people amused and interested until they make up their minds whether or not they will spend a couple of dollars.

There may be landing platforms on the tops of buildings in the near future, but I doubt it; it takes an exceptionally good pilot to land on the top of a building.

Size and Capacity of Airports

CHAIRMAN W. LAURENCE LEPAGE[3]:—I think it will not be very difficult to land on a good-sized roof with an Autogiro.

The clause in the regulations of the Lehigh Airports Competition requiring all buildings and facilities to be such that they can be adapted to twice the designed capacity, without removal or abandonment, strikes the keynote of present development.

Two influences will affect the necessary size of airports in the future. The first is the increase in commercial aviation that may be expected, and the consequent increased use of airports; and the second is the technical development of the airplane, which may make possible landing within smaller and smaller areas. It is possible that the two will tend to cancel each other, and that airports of 500 or 600 acres, such as we are planning today, will be large enough to accommodate a vastly increased number of airplanes.

NORMAN G. SHIDLE[4]:—Protection against the erection of high buildings within a considerable area around an airport seems to be very important. As a layman, I am greatly interested in devices such as the Autogiro, which may have a great influence upon the possibilities and requirements of airports.

MR. JOHNSON:—What I have said refers to airplanes of the present type and the tendency of larger planes with heavier loads to require more room for taking off. I would not advocate loading in the center of the field, as a general thing; it depends upon the layout and size of the field; buildings in the center of the field are not a hazard provided the field is large enough to accommodate them.

FRANCIS KEALLY:—The Japanese have, for a number of years, used the plan of having buildings in the center of the field. With a large enough field, the plan is fine for controlling traffic. Landing planes come directly to the center of the field, and planes can take off directly from the buildings. In the ordinary field, with the buildings at one end, it may be possible for landing airplanes to stop at the buildings to discharge passengers, but departing planes must taxi with their passengers to the opposite end of the field before they can take off into the wind.

A large city probably will need several airports, and the possibility of accidents will be reduced if one is used only for landing and another only for taking off. It may be better for small neighboring cities to build one large airport rather than several smaller ones, and to separate it into ingoing and outgoing terminals. A pilot told me recently that he had had much difficulty with waiting in the air for an opportunity to come down. This is a dangerous condition which would be avoided if there were separate fields for landing and for taking off. I noticed in Berlin this summer that the airport has a municipal traffic officer to control all the airplanes, and a plane is not allowed to land or take off until the pilot receives a signal from the officer.

Access to Port and Buildings

QUESTION:—What arrangements would be made for people entering the field to reach the central buildings in safety?

MR. KEALLY:—Our plans call for tunnels under the field. Another way is to bring the passengers across the field from the east and west when the wind is blowing from north or south. There is a possibility that future airports will be combined with railroad stations, trains coming in under the landing-fields and passengers entering immediately under the airport terminal.

KERN DODGE[5]:—Time-distance to the airport is largely a question of surface conditions. Pneumatic tubes will transport the mail, but passengers are of more importance, and most of them will come to the port in automobiles, even if subway transportation is provided. The average distance traveled by a letter will be greater than that traveled by a passenger, so

[3] Jun. S.A.E.—Assistant to vice-president, Pitcairn Aviation, Inc., Philadelphia.
[4] M.S.A.E.—Directing editor, Chilton-Class Journal Co., Philadelphia.
[5] Consulting engineer, Philadelphia.

the time-distance will be of greater importance with the passenger.

What is a reasonable size for a municipal airport, considering that each large city will have several airports? Is 200 acres enough, or should it be 400 acres or more? If the field is very large, will it be economical?

MR. JOHNSON:—We consider the 335-acre airport in Dayton large for a city of that size. Lyons Field, in Los Angeles, has 640 acres. It will not be economical to have too large a field for the business that is to be done, but a large field can be divided into sections and part of it used for school work, which is very important. Training flying amounts to more than 2,250,000 miles each year in the United States, and provision should be made for school work at large fields in the Country. Kelly Field, at San Antonio, Texas, which probably is the greatest training center in the world for military pilots, is divided into several sections.

A field containing 400 acres would be a large field for ordinary commercial flying, but, if the ground is to be divided and a large part of it used for school work, 900 acres would not be too large.

MR. DODGE:—It is an important question whether it ever will be practicable to permit student flying on a field that is used also for commercial flying. My feeling is that the student flying must be at separate fields, and there is no reason why training fields should be located very near to a large city.

C. C. TRUMP[6]:—Airports should combine provision for all classes of transportation. What is to be done with the big dirigibles? The large airplanes and airships will go first to the cities where provision is made to receive them.

W. LAWRENCE SAUNDERS[7]:—Facilities for railroads and shipping will be available at the Hog Island site in Philadelphia. They are considering the erection of a dirigible mast, possibly a disappearing one, at the edge of the field, so that the dirigible will float over the proposed sewage-disposal.

W. S. BORDEN[8]:—Mercer Field, located at Trenton, N. J., and maintained by the Board of Chosen Freeholders of Mercer County, comprises 200 acres. Many of our people urged us to provide the community with an airport, and we felt it incumbent upon us to provide a field large enough so that flying from it might be as safe as possible.

The field is located on high ground and was acquired at a cost of $50,000. The drainage system cost $15,000, and the 80 x 100-ft. brick-and-steel hangar cost an additional $50,000. The field is slightly saucer-shaped and consequently has exceptionally good drainage. It has been graded and seeded and a clubhouse has been provided.

[6] M.S.A.E.—Vice-president, Terminal Engineering Co., Philadelphia.

[7] President, Aero Club of Pennsylvania, Philadelphia.

[8] Director of Finance, Mercer County, Trenton, N. J.

Selling Passenger Air-Transportation

SELLING a ticket for a man or woman to ride in an airplane differs from selling a ticket for a railroad, steamship or motorcoach trip. The difference lies primarily in the fact that the public is accustomed to ground or water travel and has not yet become used to air travel. Scores of times you have met the man who says: "Oh, no; I want to keep one foot on the ground." And the next day he may read in the morning newspaper about some airplane accident and decide that he wants to keep two feet on the ground. Probably the cracking was done by some stunt flier, for accidents on regularly established commercial air-passenger transport lines are rare. The reliability and on-time records of our properly operated commercial airlines rival those of the best of any other transport systems known to the world.

In our own organization we never mention the word "safety." Instead, we talk of reliability; we dream it, preach it and prove it. In support of that policy, we avoid the word "flying." We say "travel by air."

There is psychology in this salesmanship. If you talk to a man about being safe in the air he is mentally answering "maybe." On the other hand, if you talk to him about the reliability of the engines and their perfection, the strength of the construction of the airplane, the dependability and experience of the pilots, he will have no mental reservation.

If you talk to a man about flying, he knows that the airplane may fly but that he cannot do so himself. He can and does grasp the thought of traveling by air, which suggests nothing that is impossible. Why should we not concentrate upon the slogan, Travel by Air?

We in the aerial passenger-transport service have found that we can sell passenger tickets if we give the passenger more than he expects, and give it to him with a smile. The prospective passenger expects immediate attention. It is peculiar to the air-transport service that the buyer of a ticket for air travel feels, for some unjustified reason, that he is doing the transport company a particular favor. He has not the same feeling toward any other transport service. This peculiarity will be overcome in time, but meantime we in the aviation industry must exercise courtesy to the highest degree. We can never dispute with even the most fanatic anti-airplane bigot; we have to let him rant while we smile; to tell everything he does not know about what an airplane cannot do and be happy about it. That is one of the hardships of selling air passenger transportation. We of the aviation industry have heard innumerable nonsensical objections to air travel, but we are overcoming them by selling the thought of reliability, by practising courtesy and emphasizing the slogan, Travel by Air.

We are trying to make the people believe that if their time is valuable they should travel by airplane. We do not have a word to say against any of the older means of transport; they are our friends and we are friendly to them; they have taught us a great deal and we have tried to appropriate and make use of every good idea they have created during the last 100 years. But increasing thousands of Americans are learning that air has more than one use. The aerial passenger-service is going forward by consistent and persistent effort; by proving reliability, by constant and sometimes exalted courtesy, we are inducing the people of the United States to Travel by Air.—Hal Shields, in a paper presented at the Aeronautic Meeting of the Society in Los Angeles.

The Coordination of Aviation and Ocean Travel

By LIEUT. W. M. FELLERS, U.S.N.[1]

METROPOLITAN SECTION PAPER — *Illustrated with* PHOTOGRAPHS

POSSIBILITIES of successful operation of commercial aircraft between ports and ocean steamships at sea are discussed in the light of 12 years of experimenting by the Navy with shipboard aviation. The physical possibility of operating airplanes from a shipboard base have been conclusively demonstrated and many of the problems have been solved. All the information gained by the Navy in these experiments and practical operation of aircraft with the Battle Fleet are available to those contemplating establishing a commercial service between ships and shore.

The author regards such a service in conjunction with transatlantic shipping as possible of profitable operation from the start if well planned, equipped and operated, but advises operating only from ship to shore and carrying only mail and express until experience has demonstrated the practicability of carrying passengers. Difficulties of operation in the reverse direction are pointed out and the use of seaplanes and of catapults for sending them off from the deck of the ship is held to be essential with the present ships.

Fog over the ship lanes would make the picking up of a ship several hundred miles out at sea almost impossible, and a plane would need to carry enough fuel for the return flight to land, which would cut down the pay-load. Use of a landing-deck on shipboard seems to be the only practicable method of getting an airplane on board, and to construct on present ships sufficiently large landing-decks to be safe would be prohibitively expensive. Seaplanes cannot consistently land in the sea alongside an ocean liner and be hoisted aboard safely.

Weather conditions are very severe on the west side of the Atlantic in the vicinity of New York City. Ships could alter their course a little to the south of the usual west-bound lane, upon receipt of radioed information, and send the planes off under sufficiently good conditions. Weather Bureau reports and data on which pilot charts are based are available for thorough study of the weather factor.

THE United States Navy has been experimenting with shipboard aviation for 12 years. For the last 4 years aviation has been an integral part of the United States Fleet. Airplanes have been carried by vessels of the fleet as a part of their regular equipment. These planes have been launched from the ships, have carried out their missions and returned to their ships directly, making use of a shore base only for occasional major repairs or overhaul. The physical possibility of operating airplanes from a shipboard base has been conclusively demonstrated, and many of the problems involved have been solved. Commercial aviation may avail itself of all that has been learned to date and start off from the place that Naval aviation has reached after all these years of effort.

It seems possible that a commercial airplane service that is well planned, equipped and operated in conjunction with transatlantic shipping may be profitable from the start, and that it is only a matter of time before it will be thoroughly exploited. The simplest and most practicable way to enter this field seems to be with a ship-to-shore service, handling only fast mail and express until sufficient experience has demonstrated the practicability of passenger carrying. Seaplanes would leave the ship from a catapult, as shown in Figs. 1 and 2, and land in a harbor close to railroad and post-office facilities. A shore-to-ship service with present ships, airplanes and equipment would encounter greater difficulties and its inauguration might well be postponed until ship-to-shore service has been proved a success.

Among the first questions asked by a financier would be, How long will it be before non-stop ocean flying between the continents becomes a commercially successful business and takes all of the high-speed traffic? There are few persons today who do not believe that aviation will solve its problems and that even non-stop Pacific flights will be made with regularity and safety. Those of us who are better acquainted with the present and past characteristics of airplanes, and who know how the development of the art of flying has been brought about, may have our noses too close to the grindstone to see the future clearly, but we believe that merely increasing the size of airplanes or of refining their design will have little effect on their capacity to carry pay-loads over long distances. The introduction of a new alloy, much lighter and stronger than those now obtainable, would increase capacity or range; the discovery of a new wing-form having a much better ratio of lift to resistance than any of the thousands of airfoils that have been tested would help; the invention of a much more efficient engine, based on both weight and fuel consumption to output, or of a fuel having many more usable heat units per pound, would solve the problem in short order. However, extrapolation of the curve of progress leads one to believe that non-stop transatlantic flying with a commercial pay-load is not sufficiently near to be a factor in determining the obsolescence charge against equipment necessary for a shipboard airplane service.

The length of time a military airplane is regarded as the best obtainable for the particular service for which it is designed is exceedingly short; sometimes it is less than a year. The airplanes are not total losses after that period but are used for other types of service, sometimes for as long as 10 years, and may be safe and serviceable for this secondary service. Commercial airplanes would not become obsolete so quickly.

[1] Bureau of Aeronautics, Navy Department, City of Washington.

To a certain extent the military and commercial planes bear the same kind of relationship to each other that the motor-truck or the sedate family car of the more expensive makes bears to the roadster built especially for sportsmen. The sportsman wants the best available and the military aviation must have it to be effective against a possible adversary. Commercial airplanes should be useful in their first service for four or five years, then have a reasonable second-hand value.

Difficulties of Shore-to-Ship Service

Unless one has flown several hours over the sea out of sight of land, it is hard to realize how vast the ocean is and how little space, relatively, a big ship occupies. To overtake and find a ship 300 or 400 miles out at sea is such a difficult task that no aviator would be justified in attempting it with passengers or valuable freight on board unless he had sufficient fuel to return to land. The world has recently been astonished by the accuracy with which some flights have been made. The particular ones in mind were accomplished only with a compass and air-speed meter for navigating, and part of the flights was through the night or fog. This type of navigation would be totally inadequate in locating a ship, because the slightest undetected or inaccurately estimated side-wind would result in missing the ship completely. Navigation using the sun, moon, and stars is practicable from an airplane provided these bodies can be seen, but the main dependence of a shore-to-ship service will be some form of radio compass or direction-finder. Remarkable results have been obtained with both these devices, and we may confidently expect that practicable instruments will be available in the near future; but, until these radio instruments are perfected so that interruption of service because of mechanical or atmospheric conditions is very rare, it will be necessary to retain enough reserve fuel to return to a shore base. The reduction in pay-load or lessening of the radius of action brought about by the necessity of carrying this reserve fuel would be a big factor in the ability of a shore-to-ship service to pay its way at present.

There are other factors. A seaplane was proposed for the first service because it can land in a harbor close to distributing facilities, whereas landing-fields for landplanes usually are more distant from such centers. Another reason is that a seaplane is more seaworthy than a landplane equipped with emergency flotation-gear and could rest on the water to await rescue, in the event of a forced descent, under more severe conditions than could the landplane.

However, the practice of landing a seaplane on the sea and awaiting rescue is, in a measure, comparable to taking to lifeboats. In times of stress it holds out a promise of ultimate safety that would not be lightly given up, but it is not to be included as a part of the routine. It is the consensus of opinion of several Naval officers who have studied the question that landing on or taking off from the North Atlantic as a regular practice for commercial planes would be impracticable because of the large proportion of the time such landings and take-offs could not be made with safety or success. A 25-m.p.h. wind blowing for any considerable time would kick up too much sea. It is doubtful if many passengers could be found who would subject themselves to the discomfort attendant upon landing in even a moderate sea after once having experienced it. By skillful manipulation of his vessel, the captain can help the aviator considerably. He can create a slick and a lee in which the airplane can land with more safety than otherwise, but in many cases this would merely decrease the difficulty of landing in rough water, not overcome it.

Methods of Getting the Plane Aboard

Airplanes do return to the battleships and cruisers of the fleet and land alongside, after which they are taken aboard by means of a crane. And they do this under conditions that are extremely difficult. Frequently the conditions would cause such a procedure to result in so large a number of casualties that it would not be worthwhile unless, as is often the case, the mission of the plane could be accomplished before returning to its ship and was of sufficient importance to warrant the expenditure of material and personnel that would result. The enemy would experience the same conditions and, unless he had better material or more skillful personnel than we had, his losses would be as great or he would be forced to lose the use of his planes. Hoisting an airplane aboard a ship of high freeboard is another difficulty. The plane hanging on the end of its hoisting line from the crane would have sufficient motion communicated to it from the rolling ship to set up a pendulum action and would tend to smash itself against the side of the ship because lines to

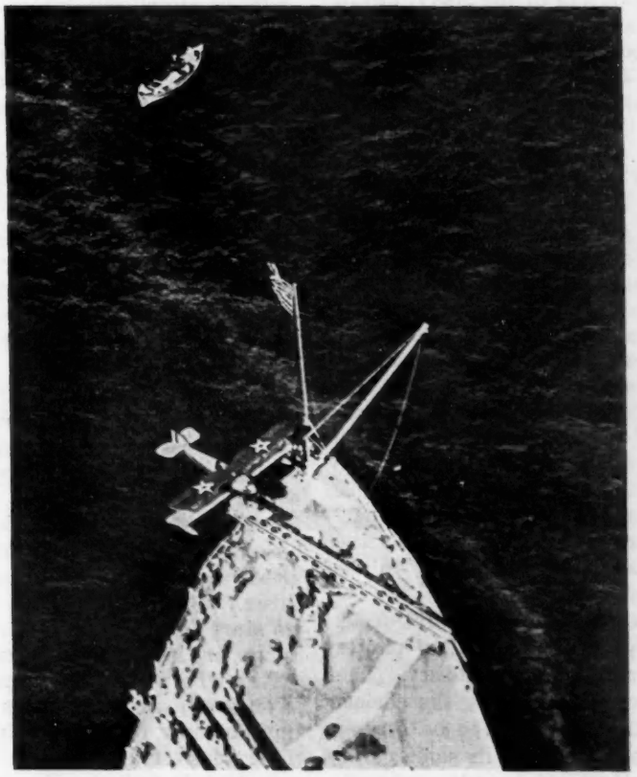

FIG. 1—SEAPLANE READY FOR CATAPULTING FROM DECK OF A BATTLESHIP

prevent inboard motion could not be tended. The steamship would necessarily be dead in the water, broadside on to wind and wave to create the lee and to allow the crew to hook the plane onto the crane fall.

The practice of dropping mail on the deck or of catching it in a net or on a hook could be developed into a workable form, but there would still be the necessity of the airplane returning to shore with a loss of pay-load capacity due to the extra fuel that would have to be carried.

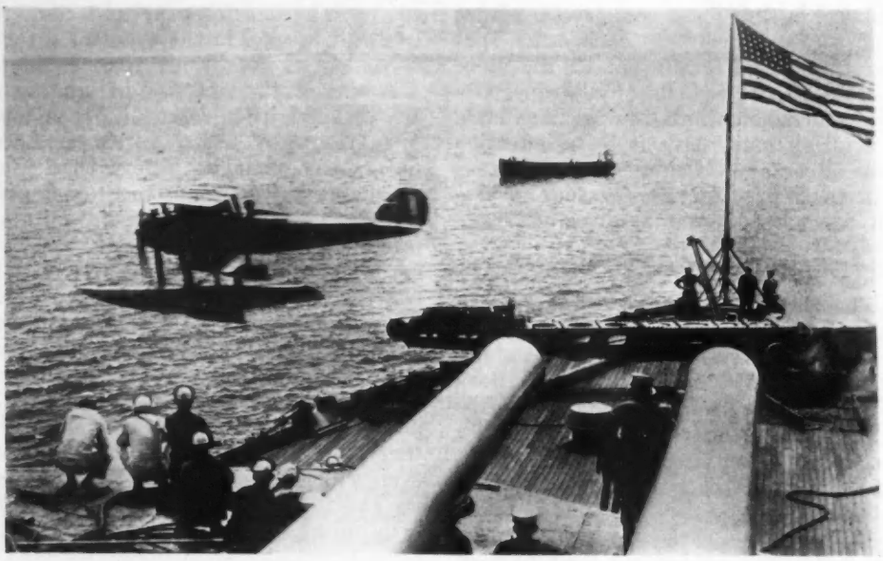

FIG. 2—LEAVING THE CATAPULT AT ABOUT 60 M.P.H. AFTER LESS THAN 1½ SEC. FROM REST

The use of a landing-deck seems to be the only practicable method of affording a safe landing place for the shore-to-ship airplane. A new type of passenger ship has been projected with a complete flight-deck similar to those on the new carriers of the Navy, affording a clear runway almost as long as the ship and of sufficient width to make landings and take-offs practicable. These ships will be, in effect, floating landing-fields. Both ship-to-shore and shore-to-ship service will be possible within certain limitations of fog, snow, sleet, heavy rain and wind. Multi-motor landplanes or amphibians will probably be used so that the deck can be used for both take-offs and landings. A heavily loaded plane could be taken off from such a long deck provided too much of the space was not filled up with other planes. The ship-to-shore flights would be made at first only under ideal conditions, and, as experience was gained and navigation made more sure, the length and frequency of these flights would be increased. It is possible that a seaplane, capable of both landing and taking off from a flight-deck, could be devised, but undoubtedly the development of the amphibian would keep pace with it and the amphibian would be of more general use. Ships of the flight-deck type will cost more to build than the conventional ones, and their commercial success will, in large measure, depend upon the efficiency of their financing and on their ability to obtain high-tariff freight in sufficient volume.

To convert present ships to ships having flight-decks large enough for safe landing and taking off of planes seems to be of doubtful commercial possibility. The concentrated loads imposed on such decks by the wheels of airplanes would require the structure to be strong and heavy, the cost would be great, and in some cases the stability of the ship itself would be adversely affected. It is not intended to convey the impression that it could not be done, but that it would be expensive and involve many changes in the ship's structure. The plans of a number of ships were recently studied to see if sufficiently long runways for launching loaded planes could be located at the forward end. The conclusion reached was that such runways could not be built without making major changes to the ships, and that the use of catapults was more practical and would involve less expense than the constructing of such runways.

Practicability of Catapulting

The reason the ship-to-shore service with catapult launching was recommended for consideration before a more ambitious one is attempted is because of its relative simplicity, reliability, low cost and safety. The operation of such a service for one year would enable those operating it to learn many things of value and to solve in advance many of the problems that would be confronted when the shore-to-ship service was started. Planes can be catapulted, without adding in the least to the hazard of the operation, in any weather in which they can fly and under conditions that would render taking off from the water absolutely impracticable. A plane may leave a ship when weather conditions are not good provided the weather ashore is fit for flying. This difference in weather conditions at sea and ashore will exist frequently. Owing to the influence of the Gulf Stream and the Labrador Current, the ship lanes off New York City are foggy more often than the harbor.

Stresses induced in the plane by catapulting and the forces acting on passengers and crew are not excessive. It is necessary to provide for them, but the extra strength of structure is confined to a few members and has no appreciable effect on the plane's performance. No discomfort attends a launching by catapult, but as an experience it is not likely to be forgotten. Our Service catapults give an acceleration of between two and three times gravity. (See Figs. 1 and 2.) As a result, we start from rest and reach a speed approximating 60 m.p.h. in less than 1½ sec. An inexpert automobile driver who races his engine and quickly lets the clutch in on first gear experiences an equal or greater acceleration but only for the briefest moment. A catapult continues delivering its push throughout the run and the sensation is unique. The cessation of horizontal acceleration at the end of the run produces almost as pronounced a sensation as the original sensation.

Everything in the airplane, including the personnel, must be secured against relative horizontal rearward motion, but there is no discomfort and the whole action is over before one has much time to consider his sensations or analyze his emotions.

Weather Conditions Over the Atlantic

For a preliminary study of weather conditions to be expected in any part of the navigable oceans at any time of the year, the pilot charts of the Hydrographic Office are invaluable. They show that conditions are, on the average, more severe at all seasons on the western than on the eastern shore of the North Atlantic. For instance, between New York City and 900 miles out, fog has been sighted about 15 days out of 100, whereas, on the other end of the route, fog has been sighted only about 8 days out of 100. Lower temperatures also are encountered on the west side. The charts show that a marked improvement in weather conditions would be obtained by sailing a little farther south than the regular ship lanes. The fog and temperature gradients are very steep along the Atlantic seaboard in the vicinity of New York City, so a ship could alter its course a little to the south upon information radioed to it from shore and send its planes off in reasonable weather, when the weather conditions in the lanes were poor. The records of the Weather Bureau and the data on which the pilot charts are based are available for a really complete study of this question of weather.

It is not the intent in this paper to discourage any properly equipped organization from attempting an airplane and ship service. Such a service is possible; the records show that it can be safe; the Navy has pioneered in this work. During all of the intensive experimentation and operating work involved in the launching of thousands of planes from more than 30 ships and the arresting of several thousand others on the carriers, we have not lost a man or broken a bone in any accident due directly or indirectly to either of these operations. We frankly admit that in several instances the almost apparent intervention of Divine Providence has served to keep the record clear. Neither is it intended to convey the idea that great profits may be made immediately by commercial shipboard aviation. However, it seems to be of sufficient promise to warrant a careful and detailed study of the problem by organizations that may be in a position to provide such a service.

Making Life Safe in Outboard Boating

SAFETY features available for those who go in for driving outboard-engine motorboats include life-saving vests and other similar devices. With the spread of the use of the outboard-engine boat, the need of personal safety has become a reality, not so much with the racing drivers, because they are able to control it, as with the private boat owner Rules for racing are so stringent that when a man takes part in a regatta and it is not clear that he is properly supplied with life-saving equipment, the boat is ruled off the course and he is disqualified. An experienced race driver is never seen out in a boat without a life vest on, preferably one with a collar, so that if he is thrown from a boat and knocked unconscious his head will stay up and out of the water.

The same conditions apply, to a less degree, to the use of the family-type boat. There the chances of trouble are minimized, as air mattresses and cushions are available, and they should be required as a part of the equipment for any family boat. If he is in a high-speed boat, one never knows when he may go overboard. The water becomes increasingly hard the faster the speed is, and surprisingly hard when going more than 30 m.p.h.

We are trying to preach that everybody in racing boats should wear life vests. It is not a sign of fear or of being childish, but of common sense. Government regulations do not apply to hulls of family boats under 16 ft. in length, but require a boat over 16 ft. long to carry, for every person in the boat, a life vest or a life cushion capable of supporting an adult person. If the same rule is applied to smaller boats the idea is not far amiss. The cushions do not take much room, and last year a new tubular type of air device was developed, weighing probably less than ¼ lb., which when inflated will support an adult person for an indefinite time.

In racing we have reached such a high speed that nobody knows what will happen when the race starts. The pilot may be thrown from his boat directly in front of oncoming boats going too fast to avoid him, in which event he is exposed to the danger of the impact of the blow or the far greater danger of a propeller blade striking him on the head. I know of no helmet, light enough for practical use in outboard racing, that is designed so as to protect a man's head from the propeller if he is thrown into the water.

In the event of a man's being thrown from his boat and knocked unconscious, he probably will be brought to the surface with grappling irons unless he has on a life vest with a collar that keeps his head above the water until he is picked up. Anyone using boats of this kind should pay attention to that simple matter of having some device in the boat for the protection of his own life and the lives of those in the boat with him.—Prof. Dean Abner Fales, Massachusetts Institute of Technology, at a joint meeting of the New England Section of the Society of Automotive Engineers and New England Outboard Motor Boat Association.

Spinning Characteristics of Airplanes

Discussion of Dr. Michael Watter's Metropolitan Section Aeronautic Division Paper[1]

DISCUSSERS who narrate some of their experiments and experiences in spins agree with most of the statements made by Dr. Watter in his paper, including the assertion that very little definite knowledge of flat-spinning is possessed. Some maintain that the spin is an essential defensive maneuver in military aviation. "Flat spin" is thought by one to be an incorrect term for the peculiar dangerous spinning phenomena, as the attitude of the airplane may be either flat or at a very steep angle. The speed at which a pilot goes into a spin and the order in which he operates the rudder and stick is said to have much to do with the development of the spin, the general attitude of the plane, and the time of recovery. Modification of tail surfaces has overcome bad spinning characteristics in some airplanes but not in others. It has been found that any cellular arrangement probably will spin badly if conditions are right for it.

One discusser believes that an airplane that is easy to put into a spin is easy to recover, and vice versa. Inverted Frise balanced ailerons markedly reduced the flat-spinning tendency in one experiment. In another experiment, with the ailerons removed from the upper wings, the plane recovered from the spin in about one turn with reverse control. If the center of gravity of an airplane is far enough forward, a spin cannot be started at all. Increasing the area of the stabilizer and fin reduces the tendency to flat-spin but also reduces maneuverability of the plane. Another speaker found that the rudder is much the most important control surface in recovery from a spin, and thinks that in commercial aviation the ounce of prevention against getting into a spin is worth the proverbial pound of cure. In conclusion, Dr. Watter emphasizes that the problem is to find some positive control that will enable the pilot to bring any airplane out of any spin.

TEMPLE N. JOYCE[2]:—From my experience in flat-spinning tests with two types of airplane, one a biplane and the other a monoplane, which, incidentally, was not supposed to flat-spin but did, I am in accord with virtually everything Dr. Watter has said. I think he ended his paper with a statement to the effect that we do not know anything very definite about flat-spinning, and that is my opinion after having been forced to jump.

Dr. Watter mentioned the question of spinning in connection with military maneuvers. Personally, I believe that in military aircraft it is essential to spin as a defensive maneuver. When a pilot is outnumbered in a combat, it is essential that he should be able to get away. He cannot out-dive a fast pursuit plane, and a spin is a valuable defensive maneuver. In commercial aviation, I see no need for spinning, and I think we can build airplanes that do not have spinning characteristics.

Dr. Watter also said, "The transition from a normal spin to a flat spin is rather hard to describe and the difference between these two kinds of spin is usually assumed in only the relative inclination of the body."

I do not think that "flat spin" is the correct term to use as a definition for the problem we are having with airplanes at present, because the attitude of the plane may be flat or at a very steep angle. In the first of some tests I made with a certain military biplane last year, I discovered that after about 2500 ft. of spinning a very marked reversal of stick load occurred with no apparent change in the angular attitude of the fuselage. However, the recovery, which occurred after 2000 ft. of additional spinning, was distinctly delayed.

When I came down I was thoroughly convinced that the airplane had no flat-spinning tendencies. After adding 2 sq. ft. of area to the balance portion of the elevators to reduce the stick loads, I put the plane in a spin and it developed reversal of stick forces in 600 ft. instead of 2500 ft., and in subsequent spins, with the same surfaces, it got into just as flat attitudes as I have ever been in, showing that the border line between the two conditions is very small. I would rather call them delayed-recovery spins or uncontrolled spins than flat-spins.

Under Entry and Recovery, Dr. Watter says, "The entry into a spin can be subdivided into voluntary and involuntary, depending upon whether the pilot intends to execute a spin or must face it as a consequence of peculiar behavior of his craft under certain conditions."

Factors That Affect Nature of Spin

From my experience, a plane can be put into several types of spin. On one occasion at Anacostia with a conventional pontoon-equipped Naval biplane that had flat-spinning tendencies, I went into the spin at a velocity of about 90 m.p.h. When I kicked the rudder the plane went into one of the fastest, steepest spins I have ever been in in my life, with the nose down almost vertically and the plane rotating at a very high velocity. In two or three attempts that afternoon, I was unable to reproduce that same spin; the best I could get was a flat attitude of the airplane. Consequently, from this one experience it may be seen that the way in which a pilot enters a spin, whether he kicks the rudder first and pulls the stick afterward or pulls the stick and then kicks the rudder, or whether he goes into the spin at 40, 60 or 90 m.p.h., has a great deal of bearing on the

[1] The paper was printed in the May, 1929, issue of S.A.E. JOURNAL, p. 474. The author is design engineer of the Chance Vought Corp., Long Island City, N. Y., and is a Member of the Society. A brief abstract of the main points of the discussion, nearly all of which was oral, is given above.

[2] A.S.A.E.—Vice-president, in charge of sales and military development, Berliner-Joyce Aircraft Corp., Baltimore.

development of the spin, the general attitude of the plane and the time of recovery.

One other important point I want to mention. Dr. Watter said that apparently no tests had been made with the Handley Page slot in connection with flat-spinning. I have put the military plane to which I just referred, which had Handley Page slots that could be locked, into a flat-spin and after it got into a well-developed flat attitude the slots were released. The lower slot came open with a report that was almost as loud as a gunshot and the plane immediately recovered from the flat-spinning attitude into a normal spin, from which recovery could be made very quickly.

There are a few minor technical definitions on which I differ with Dr. Watter but I fully agree with him that we know very little about spins and the problem is one of the most important things we have to solve.

Cannot Generalize on Recovery Means

LIEUT.-COMMANDER A. C. MILES[3]:—At the Navy Department we have got into the habit, after becoming shipmates with this bad-spinning business in the last six months, of differentiating between what we call a normal spin and a prolonged spin. We have found in most cases, although it is not entirely true, that these bad-spinning airplanes, of which there are a considerable number, will spin normally for about four or five turns, that is, the nose is well down. It has normal stick-forces, and by merely neutralizing the controls the airplane will recover without much trouble. About the only case I know that is opposed to that, as I am given to understand by Mr. Joyce, is that, with the plane from which he recently jumped, he knew he was flat as soon as he got into a spin.

We are not able to generalize at all on the means that will remedy this bad-spinning condition. Recently we have had two airplanes built to more or less the same specifications, the same wing arrangement, about the same kind of stagger, the same weight, the same power-plant. Both developed bad-spinning characteristics. By certain modifications of the tail surfaces we were able to overcome this bad characteristic in one of these planes, but we have not been able to accomplish very much with the other one, which is still a bad spinner, although the manufacturer has done much more work on it.

We have found that it is very dangerous to assume that disposition of weight alone determines the flat-spinning or the bad-spinning characteristics. We feel that any cellular arrangement, as Dr. Watter said, whether the monoplane, biplane, or triplane, probably will spin badly if the conditions are right for it.

Another thought I want to leave with you is that the reason that prominence has been given to this matter lately is that one or two very bad accidents were the result of prolonged spins. We suspect that one of the reasons we had not noticed it before is that most pilots do not enjoy spinning for more than four or five turns. The first turn is very slow; it takes a big, wide circle, consumes considerable time, and then begins to tighten up. After the average pilot has gone through three or four turns of a spin, he has had enough, and he recovers.

Hard to Spin, Hard to Recover

CHAIRMAN E. S. LAND[4]:—I should like to read an extract from a British authority on this same subject:

> After fighting with the controls from 18,000 ft. to about 7000 ft., the pilot eventually succeeded in righting the machine by moving the throttle lever and control column violently backward and forward together (I should like all pilots to note that because it is unique as a way of getting out), thereby rocking the machine out of its stable stall in the spin. It was touch and go whether the pilot remained conscious long enough to bring the machine out of the spin. Several thousand feet before recovery he had lost sight of everything and it took 20 min. of general flying around the airdrome before he was able to recover his physical and mental condition enough to trust himself with a landing.
>
> With regard to abandoning an aircraft in a spin, the experiment was tried with complete success in a slow-spinning two-seater, but on one occasion in the single-seater referred to above the pilot gave up all hope of recovery and attempted to abandon ship, but by this time he was so nearly unconscious that he could see nothing and found that he had not the strength to lift himself out of his seat. Fate, however, was with him and a moment later he realized that the machine was no longer spinning. When sight returned to him he discovered to his intense relief that he had not yet hit the ground and it was, in fact, still several thousand feet away, even though it was apparently above him.

That has elements of humor, but it has, to my mind, some very serious elements as well, and it comes from one of the best fliers in the Royal Air Force, Flight Lieutenant Riley.

I have a belief, which may not be correct, but I still cling to it, that any airplane will spin; that the easier a plane is to get into a spin, the easier it is to get out of a spin; and the harder it is to get into a spin, the harder it is to get out. That probably will not be completely confirmed, because some of these expert pilots know a great deal about it, while I am a very poor pilot and am satisfied with about one and a half or two turns of a spin. As a basic proposal, I am opposed to spinning in any type of plane, even including military types.

Experiments with Ailerons

PAUL HOVGARD[5]:—Dr. Watter has asked for data on ailerons. I have played with ailerons for some time in flat-spins. In one condition the airplane in which I have been spinning spun normally with the stick held back and in the center. If the stick should be moved to the inside of the spin, that is, to the left in a left turn, the airplane would leave a normal spin and go into a tight spiral. If the stick is moved, when in a normal spin, to the outside of the spin, the nose comes up immediately and the spin goes flat. After getting into a flat-spin, I have at times found recovery impossible without moving the stick to the outside of the spin. Once, when I was experimenting with covers to close the gap between the wing and the aileron, I started a left spin rather high and spun flat for 3000 ft., holding full-down elevator, full-right rudder and left or inside aileron, and just sat there without anything changing. Then I opened the throttle wide; the spin became much

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[3] Materiel Division, Bureau of Aeronautics, Navy Department, City of Washington.

[4] S.M.S.A.E.—Vice-president, treasurer, Daniel Guggenheim Fund for the Promotion of Aeronautics, New York City.

[5] Test pilot, Keystone Aircraft Corp., Bristol, Pa.

faster and because of the terrific vibration, I felt certain that I would recover from the spin by complete disintegration of the airplane. I was disappointed in that, but moved the stick to the outside of the spin, the force required being much greater than for moving the stick forward. The airplane recovered then in its usual 2000 ft., in five or six turns. In one experiment with different types of aileron I turned the Frise balanced-ailerons upside down. The change markedly reduced the tendency toward flat-spinning.

I found at times, that I could get a good measure of the tendency to flat-spin by the position of the control stick across the fuselage. The plane sometimes spun flat with the stick in the center and all the way back, but a change in some part of the airplane would not allow it to spin flat with the stick held in that position. So the stick position laterally may be a good indicator of the tendency of any part to make an airplane spin flat. It is necessary, of course, that the stick be held all the way back, the rudder hard over, and the stabilizer properly trimmed to obtain accurate results.

In another experiment with a landplane which was not supposed to spin flat but did so after about four turns and required five turns for recovery, I removed the ailerons entirely from the upper wings, leaving out the interplane struts. The airplane then took almost the same attitude as it did with the ailerons on but recovered normally in about one turn with reverse control, so the spin was not dangerous. The airplane would recover in about two turns even with neutral controls.

Effect of Center-of-Gravity Location

I have spun with center-of-gravity positions all the way from 38 to about 24 per cent aft of the mean aerodynamic chord. If the center of gravity is far enough forward, a spin cannot be started at all, but if a spin can be started it will go flat just as fast with the center of gravity to the rear as it will with the center of gravity forward. Changes in position of the center of gravity were made by moving the wings and without materially changing the mass distribution.

Dr. Watter suggested, I believe, that the tendency to flat-spin can be reduced by increasing the size of the fixed tail control-surfaces; that is the stabilizer and the fin. This does reduce the tendency but also considerably reduces maneuverability, which in turn can be obtained again by large control surfaces with very large balances. In later experiments, an increase of 80 per cent in area of fixed tail-surfaces reduced the number of turns required for recovery 50 per cent. Care must be taken to keep down the weight of the larger surfaces or the added area may not be worth its weight.

I also experimented with some of Korwin Krokowski's work in cellule arrangement. I found that, by using 2 deg. of positive decalage and 4 deg. washout in the wings, I could prevent a flat spin. In this condition, in a normal spin, the stick force required to hold the plane in a spin was rather high. Pulling the stick further back increased the speed of the spin considerably. As the speed increased, the force required to hold the plane in the spin or to hold the stick back increased until one either broke his back or broke the stick. So no flat spin could be obtained in that condition; the flying characteristics were horrible because of excessive stability, but the spins were good.

I believe there is a chance for control of the mass distribution in an airplane to govern the spinning characteristics. It is possible to shorten the span and increase the chord to reduce the moment of inertia of the long span, with only a slight decrease in performance. The position of the gasoline tanks also has a great bearing on the spinning characteristics.

Tail Area and Aspect Important

T. P. WRIGHT[6]:—Rather than disagree with Dr. Watter, I would place the emphasis a little differently than he did. We have found that the rudder is by far the most important control surface in connection with recovery from the spin, which I believe Dr. Watter also mentioned. With a rudder of sufficient size I believe it will be possible to recover from a spin, although that cannot be verified by fact, but certainly on the particular plane I have in mind a large increase in rudder area did contribute greatly toward making it possible to recover from any spin into which the plane could be put. Also, we found it very important to have a high-aspect-ratio horizontal tail, presumably for the reason Dr. Watter also mentioned; that is, eliminating the interference from the body while in a state of autorotation. Incidentally, it will also permit the use of an elevator having a smaller chord, which will greatly reduce the reverse-stick loads, if the particular airplane has reverse-stick loads.

I think that more emphasis should be placed on the desirability of an airplane having qualities that make it difficult to get it into a flat spin; that is, assuming that Captain Land is correct in his statement that if it is hard to get it into the spin it will be hard to get it out. Certainly in commercial aviation I should think that the ounce of prevention would be worth the pound of cure. If the airplane has such good lateral control that it is almost fool-proof, the worries about getting it out of a spin are negligible, because it will not get into a spin. Fortunately, the trend in design is toward better lateral control and larger rudders to counteract the unfavorable yawing moment of the ailerons; so we can hope for airplanes that will be safe because they will not get into spins.

The airplane to which Mr. Joyce referred that had flat-spinning tendencies, and on which Handley Page slots were mounted, was recently spun by some Army pilots. It was put into the spin with the slots open, and it was very, very difficult to get it out of the spin, even in this condition; so it seems unlikely that we shall have the beneficial effects of slots which might have been anticipated.

Positive Stagger Is Beneficial

The effect of stagger on spinning characteristics is emphasized as important by the British, and certainly in some of the tests of which we are aware in this Country the plane with marked positive stagger did have better spinning characteristics than a similar plane which did not have this stagger. I do not think the point is of great importance, although we are certain that the positive stagger is beneficial in keeping the plane from getting into the peculiar or flat spin. Probably other characteristics are of greater importance, so that, even with positive stagger, the plane can get into a flat spin; but other things being equal, the stagger is certainly of benefit.

[6] M.S.A.E.—Chief engineer, airplane division, Curtiss Aeroplane & Motor Co., Garden City, N. Y.

JOHN M. MILLER[7]:—I feel that the press has given undue prominence to tail-spins. In the Navy, in 1918, we were forbidden to stunt. I have followed that ruling ever since. In military services, a tail-spin may be necessary; in commercial service, it is not necessary. One very simple way of preventing them is to instruct the pilots not to get into them. I have been flying fairly steadily for 11 years and have never been put into a position that nearly approached a tail-spin.

Full Understanding of Spins Needed

FREDERICK W. MESINGER[8]:—Dr. Watter's paper is one more example of the thorough investigation which is being conducted in the interests of safety in flying. His treatment of the subject is extremely comprehensive and valuable.

My personal experience is confined almost solely to that gained while with the Royal Flying Corps, but it seems to me that the spin still is and always will be a valuable military defensive maneuver, particularly when a large, heavy, slow airplane is attacked by fast diving scout planes. When I flew such ships and a sudden attack at a fairly great altitude placed the larger and unwieldy machine in a dangerous position, the sole means of escape was to spin down to a lesser altitude where fast scouts were not inclined to follow on account of the strategic disadvantage of so doing. The planes we used were the old R.A.F. R.E.-8s, which had extensions on the upper wing and were notoriously easy spinners. So great was this tendency that they were not looked upon with much enthusiasm by the pilots. This tendency to spin was greatly reduced by increasing the fin area, and it was found that only a comparatively small increase had a marked effect.

C. D. HANSCOM[9]:—I should like to ask Dr. Watter if he has checked up on some of the German airplanes that have had a high elevator and the rudder located below. He mentioned the possibility that such a construction, which construction has been used to some extent abroad, might have an effect on spinning.

Problem Individual to Each Plane

DR. MICHAEL WATTER:—It is rather gratifying to note that merely theoretical engineering deductions were checked from actual pilots' experience. Mr. Joyce confirmed that an airplane that does not have any autorotational tendencies, but purely an autodynamical tendency, actually flat-spins.

With regard to the efficiency of the Handley Page slot, the question was answered by Mr. Wright. I also learned that the same airplane which was spun by Mr. Joyce and brought out of the spin by him by means of the front slot was brought out from a rather fast spin with considerable effort by a different pilot.

Mr. Hovgard apparently misunderstood me, because I was referring to the increase in stabilizing and controlling surfaces. I stated explicitly that I meant stabilizing and controlling surfaces together; that is, not only the front and stabilizer area, but also the elevator and rudder area.

I was also glad to hear Mr. Wright confirm my opinion that the rudder is of utmost importance, and I agree with him that aspect ratio of the tail should be as high as possible from the structural standpoint.

I believe from my observations that Captain Land is entirely correct in his statement that any airplane which is easily spun is usually easily brought out of a spin, and any plane which has no tendency to spin and is hard to bring into a spin is very hard to recover.

One Case May Not Help Another

I have had no personal experience with the low-rudder arrangement in combination with a high stabilizer-area, but it should be advantageous. However, I should like to reiterate that the problem of spinning is rather individual and what is good in one case may not help at all in another case. In an airplane in which the gyroscopic moments of inertia are of no great magnitude, the ailerons may be efficient and by means of improved design of ailerons alone it may be possible to recover from a spin, whereas, if the gyroscopic rolling moments are of great magnitude, we should look for other controls to help in recovery.

I believe that mere change of disposition of masses and rearrangement of controlling surfaces will be only an individual remedy. The problem confronting us and that we must solve is to find some other positive control which will enable us to bring any plane out of any spin. If the spinning characteristics of one airplane are corrected by a change of the ailerons, the claim cannot be made that a sure remedy has been found for other planes. If somebody changes the size of the rudder in a plane which was absolutely uncontrollable and the change makes it capable of recovery, it does not mean that he has solved the problem of spinning, because every airplane presents an individual problem.

Furthermore, when Mr. Hovgard told us about his experience with ailerons, he mentioned that he was noticing rather carefully the location of the stick across the fuselage. It should be pointed out that the attitude of the stick across the fuselage is only one point in the spinning characteristics of the airplane; if his stick was not located in exactly the same fore-and-aft position, the condition of spinning was entirely changed. There are cases in which the plane spins very fast with the stick all the way back, and when it is brought slightly forward the plane spins still faster. That indicates again the importance of balance of aerodynamic and dynamic masses. Any remedy which deals with the disposition of controls as they are today is only a remedy for an individual case and is not a general solution of the problem. What we must look forward to is a definite means which will correct dangerous spinning tendencies of any airplane.

As regards the terminology, I used the term "flat spin" because students of spinning literature are accustomed to associate with flat spin also a dangerous spin. But I pointed out in my paper that there are other attitudes of the airplane; that, to spin dangerously, it is not at all necessary that the airplane should be almost level, and that some planes spin very dangerously and are unable to recover when they are in other attitudes.

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Economies of Metal Airplane-Construction

By George H. Prudden[1]

Los Angeles Aeronautic Meeting Paper

MASS PRODUCTION of airplanes, the author holds, can be attained only when machine processes generally take the place of hand work. This premise indicates the advantages of metal over the use of wood and cloth in airplanes, all structural problems being capable of solution with a metal of sufficient strength and lightness.

Processes for making duralumin into airplane parts are described. Heat-treating is of special importance and automatic heat-control is necessary to obtain satisfactory results in an economical way.

The author points out that duralumin is not easily drawn and that a special technique must be observed in making bends. Having a grain, the metal must be protected against scratching. The design must also aim at rapid and complete dissipation of stresses to avoid vibration and crystallization.

In assembling duralumin parts, riveting is advised in preference to welding. While the squeeze gives the best results, inaccessibility of most rivets makes the use of an air-hammer the preferable method and the workmen soon become skilled in it.

WE TALK MUCH of production in aviation and some few companies have advanced toward production to a marked degree. But if we look, from a factory standpoint, at the automobile, we realize that we are still groping in the embryonic stages. Thinking only in terms of aviation, 30 airplanes a week is big production, but compared with other industrial activities it is only a flash in the pan; and until we bring the airplane completely to the machine-made stage it will remain a flash in the pan, even though we double and treble the present output.

Even though aided with the best of tools and jigs, one pair of hands can turn out just so much work in an 8-hr. day. Double or treble the pairs of hands and the output increases but the cost, exclusive of overhead, remains unchanged. Put the same work into a machine and production increases while cost decreases by squares and cubes.

The machinability of wood and cloth is very limited; and all such processes as welding and soldering, that depend on the time and skill of individual operators, greatly restrict production possibilities. Looked at from this standpoint, the metal airplane is the only answer to mass production, the goal toward which we all look, though initial costs of experimental and development work run high in this field.

Forming Immediately Follows Heat-Treating

In the choice of the metal to be employed the important question is what results can be obtained therefrom. Duralumin has proved, over a period of 10 or 12 years, a very satisfactory material here and in Europe, for both heavier and lighter-than-air construction. With its aid profitable industry has been established, and with its practical application most of the bugaboos of its early development have been driven from the lay mind. Duralumin is a 4-per cent copper alloy of aluminum which, with proper heat-treatment, gives the strength of mild steel combined with the weight of aluminum. It is subject more or less to the working processes of any other metal, except that no method of soldering it has been found.

To obtain the benefit of the strength-weight ratio of duralumin, it must be heat-treated. As duralumin remains soft and malleable after the quench for at least ½ hr., during which time forming is done, heat-treating becomes an active part of shop operation and must be carried out in a rapid and fool-proof way. Of the various methods of heat-treating that have been tried, the sodium-and-potassium-nitrate salt-bath has been found most satisfactory in spite of all of its dirt and fire hazard, principally because charges consist for the most part of work in process, which is in constant and immediate demand. The contact of molten salts with all parts of the charge results in a thorough and uniform heating of the metal in from ¼ to 1/3 of the time of the more familiar type of air furnace. There is also relatively little fluctuation in the comparatively low temperature of 950 deg. fahr. Automatic heat-control is essential not only to eliminate human error, exceedingly difficult to detect in this shop operation, but also to minimize the very expensive time-losses growing out of temperature fluctuation.

Experience has shown that much can be saved in the cost and operation of the heat-treating plant and that the possibility of untreated parts entering into the final assembly can be eliminated by forming after and not before heat-treatment. This also eliminates distortion and the need of subsequent reforming and straightening finished parts and sub-assemblies. Small and comparatively inexpensive units also tend toward greater flexibility in plant operation. Large pieces can be easily handled in a small bath before forming, by the simple and easy process of coiling before and uncoiling after treatment.

Simple Shapes and Little Working Preferable

Duralumin does not easily lend itself to deep-drawing operations and should be kept away from the bumping hammer so much as possible. Continuous and heavy working of the metal tends to harden and crystallize it and to render it unsatisfactory in service even in parts, such as cowling, that are not highly stressed. Simple

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shapes that can be quickly formed with a single operation are to be desired everywhere. No bends with an inside radius of less than three times the thickness of the metal should be attempted. Wherever corners occur, as in box shape, a hole of a radius equal to the radius of curvature of the bend and drilled at the point of intersection of bends will prevent the development of cracks during the forming operations. These holes will look staggering in size to the designer at first, but the tiny crack that will otherwise occur is of far greater consequence.

In storing and working duralumin, great care must be exercised to prevent scratches, particularly any, no matter how insignificant, that run with the grain. Duralumin has a distinct grain that runs with the metal in the rolling process. In tensile-strength tests across the grain this has no apparent effect, nor is it necessary to consider the grain when designing parts, but unless care is used in forming operations cracks will develop. Although cracks can be stopped, in a few unimportant instances, by drilling a hole at each end of them, their presence is usually sufficient to justify scrapping a part.

To prevent failure from vibration and subsequent crystallization, a point often raised in the discussion of metal airplanes, the design should be such that stresses are rapidly dissipated into the body of the airplane in every case. This aim can be accomplished by bulky fittings well secured to the adjacent structure, which should also have considerable bulk. Do not be afraid to use metal in quantity where it seems desirable to do so, for duralumin is a comparatively light metal and a few additional ounces or even pounds in the proper places will pay for themselves many times in service. In my experience a strict adherence to this principle of design has never been known to fail.

Where large bearing-surfaces and heavy fittings are required, duralumin forgings and castings of dependability will serve well. Duralumin makes a good bearing metal in places where it is subject to easy replacement, but where stresses are of appreciable magnitude it seems to have a tendency to flow, so the use of steel in such cases is preferable.

Riveting Is Unobjectionable

Riveting is among the subjects that have received most careful consideration in metal-airplane construction. It has been loosely talked about by critics who failed to realize that a riveted joint is subject to a more definite analysis and inspection than a welded one, which is commonly accepted at its face value. These critics cross riveted-steel bridges, transact their business in riveted-steel buildings and ride in riveted-steel coaches with a feeling of entire safety. Yet the only difference between the use of riveting in such structures and in an airplane is that all major assemblies in the bridge or building are made with field rivets in holes punched at the mill and subject to slight misalignment, whereas in the metal airplane no field rivets are used and all holes are drilled in assembly to assure perfect alignment and fit.

The steel rivet is inserted and driven hot. The duralumin rivet is driven in the soft state immediately after the quench, and the same result is accomplished. The hole which is only a few thousandths of an inch oversize is completely filled by expansion and the rivet is headed with a short operation that does not cause crystallization.

Of the various riveting operations, the squeeze gives the best results, but on account of the inaccessibility of most rivets to even a deeply throated squeezer the use of this method is limited. Spinning heads the rivet but does not fill the hole. The air-hammer operated under 90-lb. pressure is the most useful riveting tool, and the results of a hammer properly designed and operated leave nothing to be desired. In the operation of the air-hammer more individual skill is required than in any other step of the fabrication of the airplane, but fortunately the volume of this work is so great that men soon become skilled at it. The heaviest hammer a man is able to hold on the work is best, because it tends least to upset the crystalline structure of the rivet. A good operator can set as many as 200 rivets in an hour of continuous work.

No mystery is involved in the working of duralumin. If a few simple conditions are observed and the normal care that should be used in the construction of all aircraft is exercised, success should result. It is a sheet-metal job throughout, and good sheet-metal workers turn to it readily without special instruction. Duplicates of the machinery necessary for the work are found in any well-equipped sheet-metal shop.

An all-metal airplane cannot be successfully designed by the simple substitution of metal parts for former wooden structural elements. The result would be too complex for economy and too heavy for performance. Wherever possible, the metal must be allowed to do double duty, the surface becoming structure and the structure in some cases being also surface. By following this principle a metal airplane can be built that will be as light as the non-metallic type, at lower cost of production, and more economical and dependable in service.

Operating Factors and Engine Acceleration[1]

By DONALD B. BROOKS[2]

ANNUAL MEETING PAPER *Illustrated with* CHARTS

INCIDENTAL to the cooperative fuel-research work of the author, which has been described in another paper, was a study of the effects of other operating factors. The results of these observations are presented in this paper.

The effect of unequal fuel-distribution through the inlet manifold was studied by running acceleration tests on two cylinders at a time. Other series of acceleration tests showed the effect of jacket-water temperature with a cold inlet-manifold and of spark advance. Data are presented also from laboratory acceleration-tests simulating low-gear conditions, and showing that deceleration tests recorded by means of a spark accelerometer are useful in measuring friction under temperature conditions that are more nearly like the running conditions than are friction tests made by motoring the engine by means of a dynamometer.

THE cooperative fuel-research work on fuel volatility and engine acceleration has been described by the writer in another paper[3]. In the course of and in addition to this work, the effects of certain other factors on acceleration have been studied. This paper presents data on acceleration tests made with less than the full number of cylinders firing; on the effect of jacket temperature when the inlet-manifold temperature is low; on the effect of spark advance on acceleration; data obtained when accelerating as in low gear; and data showing the utility of the spark accelerometer in measuring engine friction.

The test apparatus has been described in the paper to which reference has been made, in John O. Eisinger's paper on Engine-Acceleration Tests[4], and in the writer's paper on The Influence of Fuel Characteristics on Engine Acceleration[5]. It consists of a 1926-model six-cylinder overhead-valve passenger-car engine having a three-port inlet-manifold, connected to apparatus imposing electrical and inertial loads such as to simulate level-road conditions, in high gear except where otherwise stated. The spark accelerometer utilizes paper tape driven by the engine, sparks being discharged through the tape at regular time-intervals.

Two-Cylinder Acceleration Tests

One of the major factors influencing engine acceleration is the performance of the manifold, particularly as regards the distribution of unvaporized gasoline. To study this point, several series of acceleration runs were made in which firing occurred in only two cylinders during each run. No electrical load was imposed on the engine during acceleration in these tests, so that they might be more nearly comparable with six-cylinder acceleration tests. Even without the load, however, the two-cylinder accelerations were only about half as large as the normal accelerations.

Test conditions prior to the instant of opening the throttle were identical with those normally used. At the instant of throttle opening, the dynamometer-field and grid switches were opened, removing the electrical load, and a switch was closed which grounded the ignition to four cylinders. At the conclusion of the acceleration, the grounding switch was opened and the dynamometer-field and load switches were closed as soon as the throttle had been closed, thus restoring normal conditions for the 3-min. idling period between acceleration runs.

Tests of the first series made in this manner were run with aviation, *D*, *E*, and *F* fuels, with manifold at —9 deg. cent. (15.8 deg. fahr.) and carbureter air cooled to —3 deg. cent. (26.6 deg. fahr.). In these, as in all subsequent tests, a normal six-cylinder acceleration test was run as a preliminary to the two-cylinder tests. The pairs of cylinders used in this series of tests were those having a common port, while in the subsequent tests cylinders were paired to give equal firing intervals. No difference in the acceleration can be positively ascribed to changing from unequal to equal firing intervals.

The results obtained with aviation, *D*, *E*, and *F* fuels vary slightly with the fuel, but show the same relative variation between pairs of cylinders. Hence only the curves for *E* fuel are shown. From Figs. 1 and 2 it is obvious that cylinders 3 and 4 gave the best over-all acceleration, although exceeded by each of the other pairs of cylinders during the interval between 3 and 5 sec. after the start of the acceleration. While cylinders 5 and 6 did not accelerate as well as 1 and 2 during the early portion of the run, the better acceleration by 5 and 6 during the latter portion of the run enabled them to pass 1 and 2 on the speed-time plot.

The tests plotted in Figs. 3 and 4 were made with U. S. Motor gasoline at nearly the same operating con-

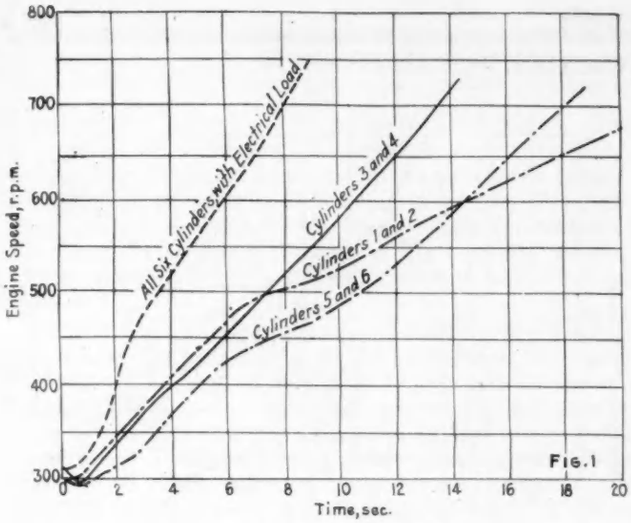
[1] Publication approved by the Director of the Bureau of Standards of the Department of Commerce.

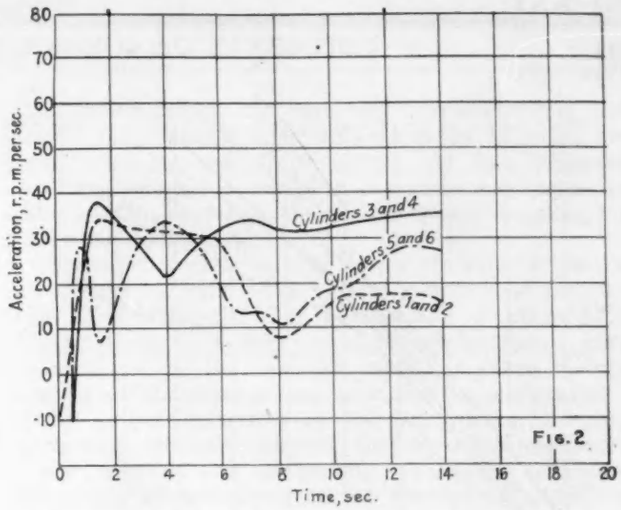
[2] S.M.S.A.E.—Associate engineer, Bureau of Standards, City of Washington.

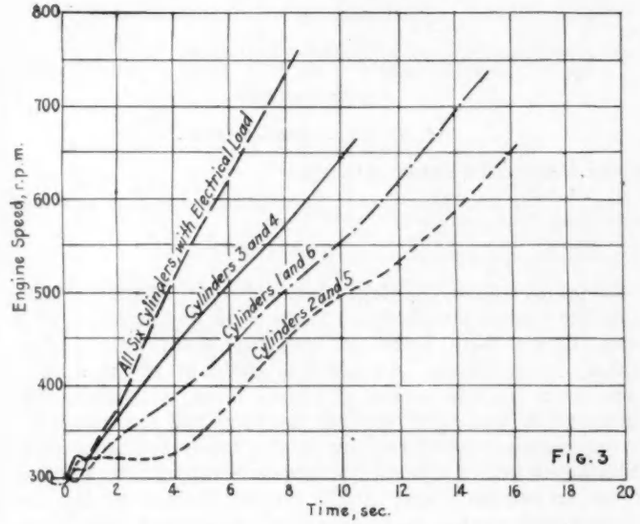
[3] See S.A.E. JOURNAL for June, 1929, p. 609.

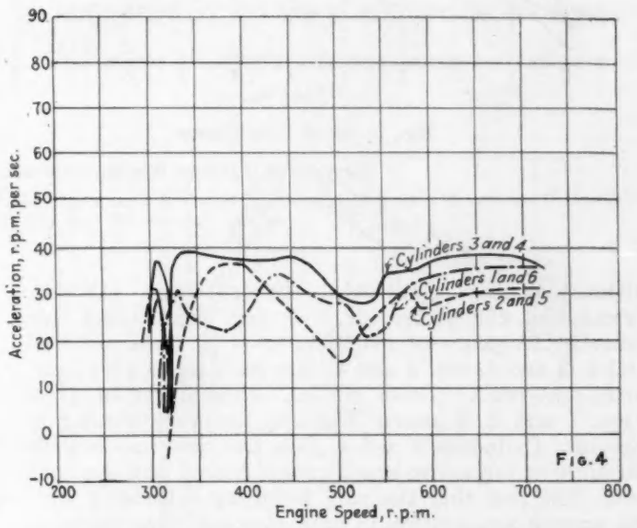
[4] See THE JOURNAL, August, 1927, p. 184.

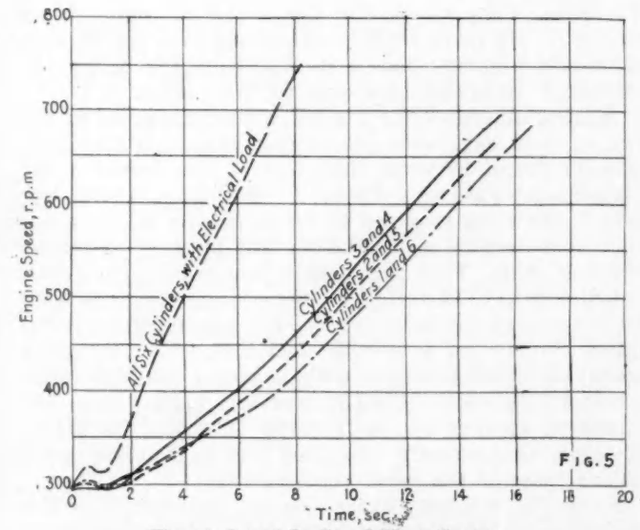
[5] See S.A.E. JOURNAL, September, 1928, p. 235.

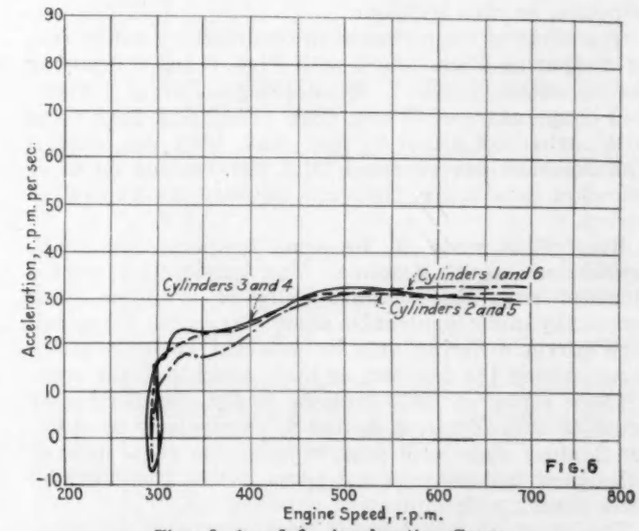












Figs. 1, 3 and 5—Speed-Time Curves

Figs. 2, 4 and 6—Acceleration Curves

STUDIES IN FUEL DISTRIBUTION BY MEASURING THE POWER FROM PAIRS OF CYLINDERS IN A SIX-CYLINDER ENGINE

No Electrical Load Was Imposed on the Engine during the Two-Cylinder Runs, To Make the Curves Comparable with Curves in Which All of the Six Cylinders Were Operating under Load

TEST CONDITIONS, FIGS. 1 TO 6

Figs.	Gasoline	Atmospheric Temperature, Deg. Cent.	Atmospheric Temperature, Deg. Fahr.	Manifold Temperature, Deg. Cent.	Manifold Temperature, Deg. Fahr.
1 and 2	Fuel *E*	—3	26.6	—9	15.8
3 and 4	U. S. Motor	—7	19.4	—10	14.0
5 and 6	U. S. Motor	27	80.6	59	138.2

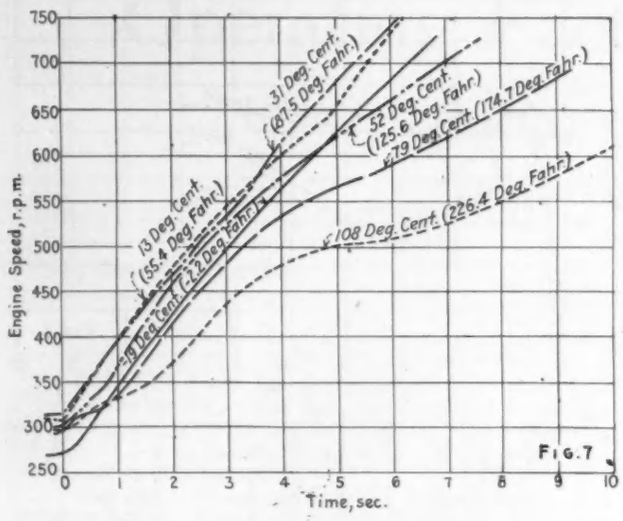

Engine Speed, r.p.m.
Time, sec.
31 Deg. Cent. (87.5 Deg. Fahr.)
52 Deg. Cent. (125.6 Deg. Fahr.)
79 Deg. Cent. (174.7 Deg. Fahr.)
13 Deg. Cent. (55.4 Deg. Fahr.)
-19 Deg. Cent. (-2.2 Deg. Fahr.)
108 Deg. Cent. (226.4 Deg. Fahr.)
FIG. 7

Fig. 7—Speed-Time Curves

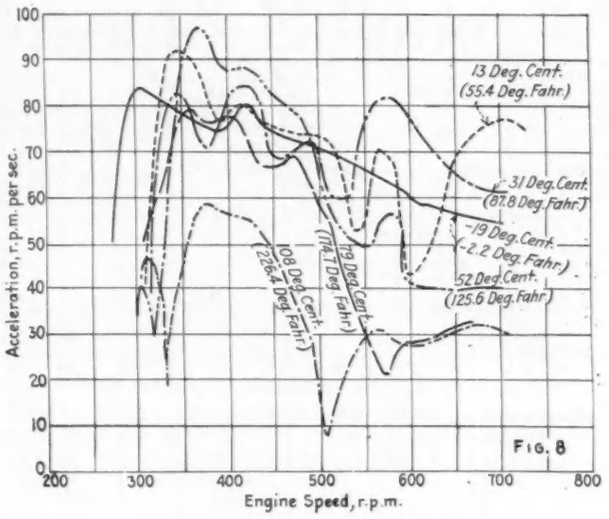

Acceleration, r.p.m. per sec.
Engine Speed, r.p.m.
13 Deg. Cent. (55.4 Deg. Fahr.)
31 Deg. Cent. (87.8 Deg. Fahr.)
-19 Deg. Cent. (-2.2 Deg. Fahr.)
52 Deg. Cent. (125.6 Deg. Fahr.)
108 Deg. Cent. (226.4 Deg. Fahr.)
79 Deg. Cent. (174.7 Deg. Fahr.)
FIG. 8

Fig. 8—Acceleration Curves

EFFECT OF JACKET-WATER TEMPERATURES WITH COLD INLET-MANIFOLD

In These Tests the Manifold Temperature Was —7 Deg. Cent. (19.4 Deg. Fahr.), the Water-Jacket Temperatures Were as Indicated on the Various Curves, and the Air-Fuel Ratio Was 9 to 1

ditions; namely, manifold, —10 deg. cent. (14 deg. fahr.) and carbureter air, —7 deg. cent. (19.4 deg. fahr.). The pairs of cylinders used in these tests—1 and 6, 2 and 5, and 3 and 4—are such as to give equal firing intervals. These curves, while differing from Figs. 1 and 2 in minor respects, are very similar in general. Cylinders 3 and 4 gave the best acceleration throughout the entire speed range, with 1 and 6 second best. The fact that the pair including cylinder 2 gave the poorest acceleration in each case indicates poor distribution to this cylinder.

The effect of improvement in vaporization can be seen by comparing Figs. 1 to 4 with Figs. 5 and 6, showing results obtained with U. S. Motor gasoline at a manifold temperature of 59 deg. cent. (138.2 deg. fahr.) and with carbureter air at 27 deg. cent. (80.6 deg. fahr.). The accelerations obtained with the various pairs of cylinders were nearly the same, as were the speed-time curves.

Runs were made at the same temperatures, using benzol instead of gasoline. The acceleration curves obtained with the separate pairs of cylinders were practically indistinguishable above 400 r.p.m., the speed-time curves differing only by constant amounts introduced during the first two or three seconds of the runs.

These series of tests indicate faulty distribution of liquid to cylinders 1, 2, 5, and 6, particularly to cylinder 2, since tests with poor vaporization show marked differences between the cylinders, while these differences vanish with improving vaporization.

The effect of jacket-water temperature on acceleration was discussed by Mr. Eisinger[6] and the writer[7] in two of the papers previously mentioned, with the conclusion that jacket temperature had little effect on acceleration under the conditions of the tests reported in those papers. In those tests, however, the manifold temperature was about 80 deg. cent. (176 deg. fahr.).

A series of tests was therefore made with the manifold temperature —7 deg. cent. (19.4 deg. fahr.), varying the jacket temperature from —19 deg. cent. (—2.2 deg. fahr.) with brine to 108 deg. cent. (226.4 deg. fahr.) with steam. An air-fuel ratio of about 9 to 1 was used in this series of tests. Even with this rich mixture it was very difficult to keep the engine operating between accelerations at the lower temperatures. The acceleration run at the lowest temperature started from an engine speed of 270 r.p.m., instead of the intended 300 r.p.m., because of the irregular operation. The speed-time curves for this series of runs, shown in Fig. 7, are more readily understood than the acceleration-speed curves, shown in Fig. 8, which reflect the extremely irregular operation of the engine.

Making allowance for the lower starting speed of the run at —19 deg. cent. (—2.2 deg. fahr.), little difference is found between the runs at the lowest three jacket temperatures. Above 31 deg. cent. (87.8 deg. fahr.), the time required to reach 700 r.p.m. increases very considerably up to the highest temperature used, 108 deg. cent. This decrease in acceleration, however, is believed to be the effect of over-rich mixtures formed by greater vaporization at the higher jacket temperatures. Supporting this is the fact that, under the same operating conditions but with a leaner air-fuel ratio, accelerations about 10 r.p.m. per sec. higher were obtained in another series of tests. It should be noted, however, that greatly increased engine friction must be overcome at the lower temperatures.

From Fig. 8 a more exact idea can be obtained of the variations in acceleration with change in jacket-water temperature. Comparing the other runs with that at —19 deg. cent., it is seen that some increase in acceleration between 300 and 500 r.p.m. occurs as the jacket temperature is raised to 52 deg. cent. (125.6 deg. fahr.); at the higher speeds, however, the acceleration decreases as the jacket temperature is raised above 31 deg. cent., and a general decrease is shown above 52 deg. cent. This also agrees qualitatively with the hypothesis that increasing vaporization at higher jacket

[6] See THE JOURNAL, August, 1927, p. 184.
See S.A.E. JOURNAL, September, 1928, p. 235.

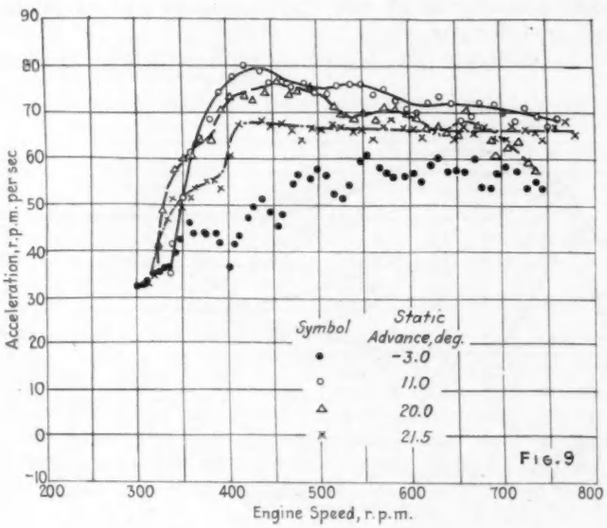
temperatures causes the decrease in acceleration. The first effect of increasing vaporization, on this basis, would be to improve acceleration at the lower speeds, possibly not affecting it at the higher speeds. The next phase would be that of little change in acceleration at the lower speeds but a decrease at high speeds. At still higher temperatures, a general decrease might be expected.

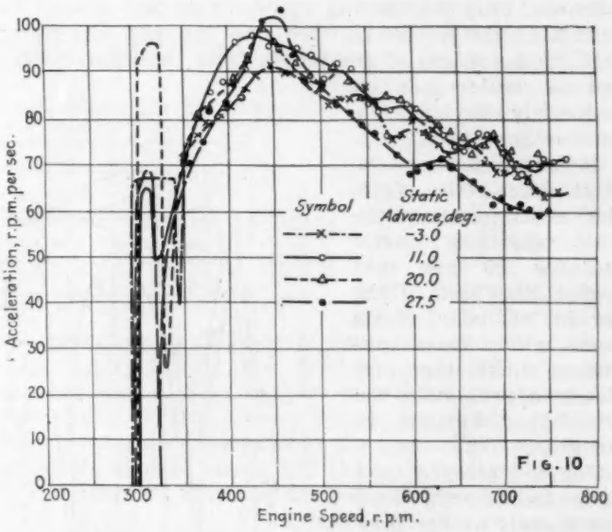
Aside from the effect of reduced volumetric efficiency, the reason for decrease is as follows: With the manifold at —7 deg. cent., relatively little vaporization can be expected to occur; a large part of the fuel is distributed as liquid, quite unequally, as the two-cylinder tests showed. More vaporization must occur in the cylinder at high cylinder temperatures than at low cylinder temperatures. With increasing vaporization of liquid fuel in the cylinders—but with the same unequal distribution, since the manifold temperature is constant—there are greater differences in effective air-fuel ratios between the cylinders. As the differences between the air-fuel ratios in the various cylinders increase, quite obviously the power at any supplied air-fuel ratio decreases[8].

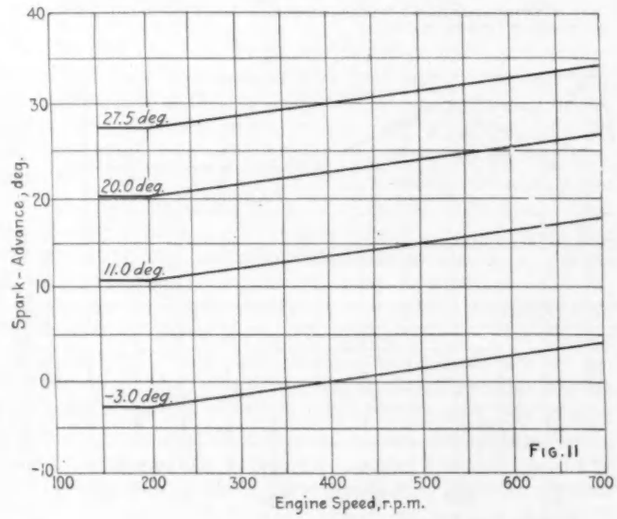
The conclusion from this series of tests is that, at air-fuel ratios sufficiently rich to assure good acceleration at low speeds, poor acceleration is obtained at higher speeds only when the jacket temperature is high. In addition, on the basis of these and other tests at low manifold temperatures, some loss of acceleration is found at both extremes of the jacket-water temperature-range studied, that at the higher temperatures being ascribed to decreasing volumetric efficiency, while rapidly increasing engine friction is believed to be responsible for the loss at very low jacket temperatures.

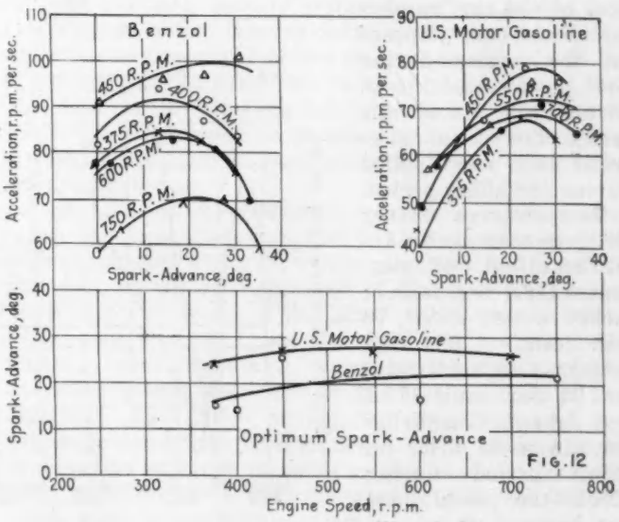
The effect of spark advance on acceleration was

[8] See National Advisory Committee of Aeronautics Report No. 189, p. 12.









EFFECT OF SPARK ADVANCE ON ACCELERATION

Fig. 9—Acceleration-Speed with U. S. Motor Gasoline

Fig. 10—Acceleration-Speed with Benzol

Fig. 11—Automatic Spark-Advance Used in These Tests

Fig. 12—Acceleration and Spark-Advance Curves

studied, using both U. S. Motor gasoline and motor benzol. Figs. 9 and 10 show the acceleration-speed curves obtained with gasoline and benzol, respectively. Throughout these tests, the semi-automatic advance was in operation, functioning as shown in Fig. 11 with the various static settings. It is apparent from the charts that the acceleration with benzol is much less sensitive to spark advance than is that with gasoline. This is due in part to the use of the same metering orifice, giving a 5 per cent richer mixture with benzol than with gasoline; and better vaporization, as evidenced by the higher acceleration with benzol, may account for the remainder.

From the upper curves of Fig. 12, which shows for each of several speeds the plots of acceleration against spark-advance, it is apparent that the effect of spark advance on acceleration is that which would be expected from the effect of spark advance on brake torque.

The lower curves of Fig. 12 show the variation of optimum spark-advance with speed. The curves in Fig. 12 are from the results of a separate run for each spark-advance, thus introducing errors from any change in operating conditions between one run and the next; but the deviations of the points from the mean curves are no greater than are ordinarily found in brake-torque tests.

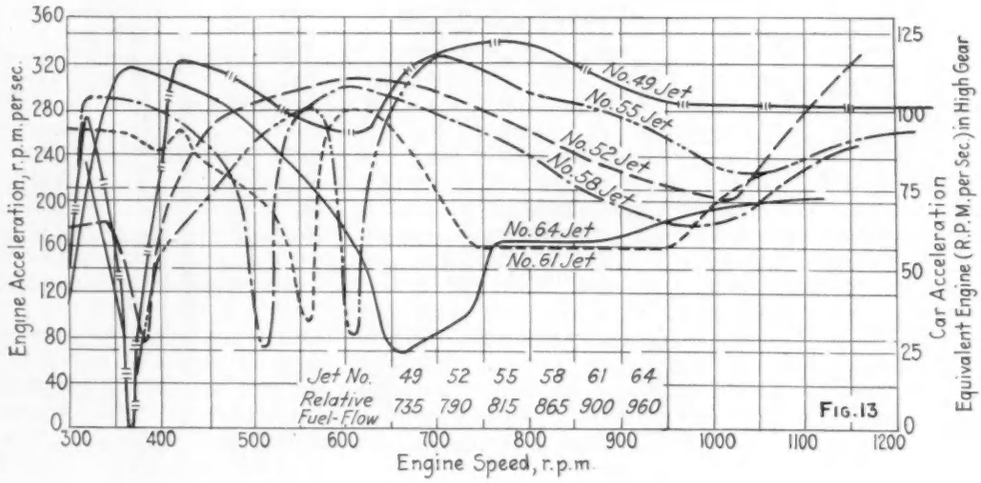
After removing the steel inertia-disc from the dynamometer, the total remaining inertia is only 10 per cent higher than that of the car in low gear. Tests made under these conditions should therefore closely approximate the actual performance in low gear.

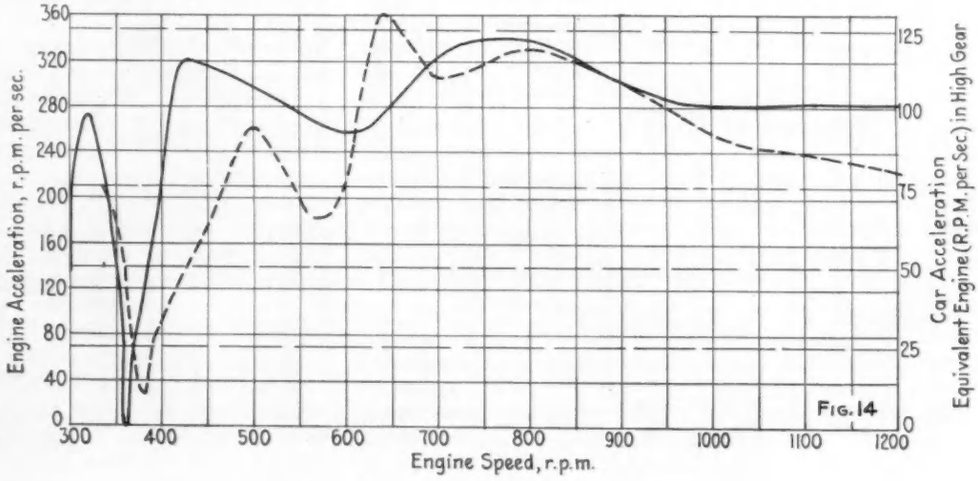
For convenience, and since the inertia load was slightly higher than that of the car, no electrical load was imposed on the engine during the acceleration tests. In only one run of this series the usual electrical load was applied during the idling period.

Temperatures during all these tests were: Inlet manifold, 47 deg. cent. (116.6 deg. fahr.); jacket water, about 70 deg. cent. (158 deg. fahr.); and carbureter air, 24 deg. cent. (75.2 deg. fahr.). Comparing the run made after an idling period during which the usual load was imposed on the engine with a run made under identical conditions except that no load was used during the idling period, the latter showed nearly twice as rapid acceleration as the former at the start but fell below the former after about 1 sec., remaining below up to 1000 r.p.m. Above this speed, no appreciable difference was shown between the two runs.

A series of runs was made, the results of which are shown in Fig. 13. Relative fuel-flows with the various metering orifices used are indicated. Two acceleration scales are given on Figs. 13 and 14. The primary vertical scales show the actual engine acceleration in revolutions per minute per second. The secondary vertical scales are intended to relate this low-gear work to high-gear tests by showing the corresponding engine acceleration in high gear which would be obtained with the observed engine acceleration in low gear. In general, it is seen that the runs made with rich mixtures give better acceleration at the start but fall short of the leaner runs above 700 r.p.m. Thus the run with No. 64 orifice gave an acceleration of nearly 320 r.p.m. per sec. at the start but fell to only 70 r.p.m. per sec. at 650 r.p.m., while that made with No. 49 orifice, falling to zero acceleration at 370 r.p.m., rose to 340 r.p.m. per sec. at 700 r.p.m.

To illustrate the degree of reproducibility in check

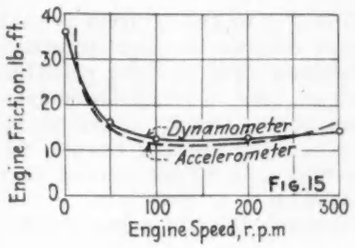

Engine Acceleration, r.p.m. per sec.
Car Acceleration
Equivalent Engine (R.P.M. per Sec.) in High Gear
No. 49 Jet
No. 55 Jet
No. 52 Jet
No. 58 Jet
No. 64 Jet
No. 61 Jet
Jet No. 49 52 55 58 61 64
Relative Fuel-Flow 735 790 815 865 900 960
Engine Speed, r.p.m.
Fig. 13

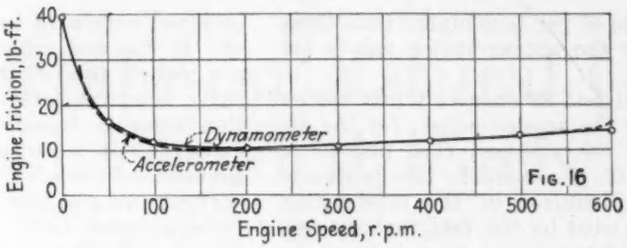


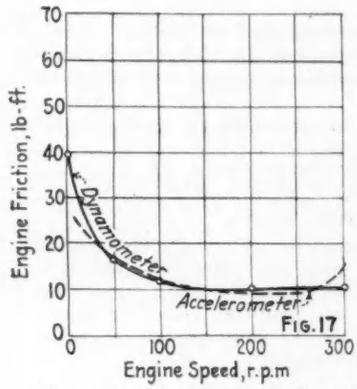
ACCELERATION TESTS UNDER LOW-GEAR CONDITIONS

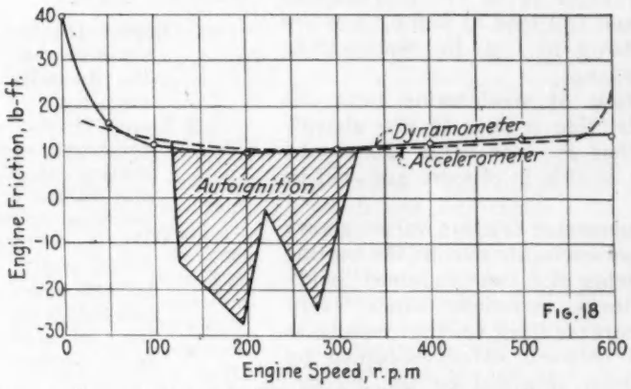
Fig. 13—Runs with Fuel Orifices of Various Sizes

Fig. 14—Two Runs with the Same Orifice, Jet No. 49









FRICTION MEASURED BY DECELERATION COMPARED WITH FRICTION MEASURED BY DYNAMOMETER

TEST CONDITIONS, FIGS. 15 TO 18

Fig.	Jacket-Water Temperature, Deg. Cent.	Jacket-Water Temperature, Deg. Fahr.	Manifold Temperature, Deg. Cent.	Manifold Temperature, Deg. Fahr.	Oil Temperature, Deg. Cent.	Oil Temperature, Deg. Fahr.	Mixture	Previous Loads
15	79	174.2	79	174.2	42	107.6	Maximum Power	Road Load
16	79	174.2	79	174.2	42	107.6	Maximum Power	Acceleration
17	78	172.4	78	172.4	42	107.6	Maximum Power	Full Load at 300 r.p.m.
18	79	174.2	74	165.2	42	107.6	Maximum Power	Full Load at 600 r.p.m.

runs under these conditions, two runs at the leanest setting were made, and are compared in Fig. 14. While some difference is evident, the low and high points have nearly the same values, and little difference is shown after the first two seconds. Runs with richer mixtures probably would check more closely, as missing was frequent during the first two seconds of these runs.

Engine Friction Measured by Deceleration

If, in the course of an acceleration or a constant-speed test, the ignition or the fuel supply is shut off, the energy stored in the rotating mass is dissipated in engine and dynamometer friction, in windage, and in any electrical load which may be imposed on the apparatus. Tests have shown that windage is negligible and that the dynamometer friction is very small and reasonably constant. Likewise the electrical load for any given setting of the dynamometer controls can be ascertained readily.

Knowing the total inertia, it is possible to determine the retarding force from the deceleration. The known small factors which have been enumerated can be deducted from the retarding force, leaving the engine friction. When no electrical load is imposed, the engine friction comprises 90 per cent of the retarding force; hence, the resulting values for engine friction are little affected by errors in the dynamometer friction. These values are believed to be correct to within 0.5-lb-ft. torque, except near the ends of the speed range.

In Figs. 15 to 22, values of engine friction obtained from the deceleration measured by the spark accelerometer are compared with values obtained by motoring with the dynamometer immediately after each test. In all cases the throttle was fully open during friction runs.

In the tests charted in Figs. 15 to 18, the inlet manifold and jacket water were maintained at about 80 deg. cent. (176 deg. fahr.). The engine friction found by the two methods is nearly the same in these four charts. In the test of Fig. 15, before the ignition switch was opened, the engine was operating at 300 r.p.m. and under a load corresponding to that imposed on it by the car on a level road. Fig. 16 shows the results obtained when the engine, after operating under road load at 300 r.p.m., was accelerated under road load to 600 r.p.m., and the ignition shut off. In the tests shown in Figs. 17 and 18, the engine was operating at full load at 300 r.p.m. and 600 r.p.m., respectively before the friction tests. The cross-hatched area in Fig. 18, part of which indicates negative engine friction, shows the results of auto-ignition which was quite noticeable at the time. The two curves are quite similar except for the auto-ignition portion.

The effect of reducing the jacket-water temperature from 79 deg. cent. (174.2 deg. fahr.) to 10 deg. cent. (50 deg. fahr.) is seen by comparing Figs. 18 and 19. The dynamometer friction-value is roughly doubled, while the accelerometer shows an increase of only 20 to 40 per cent, if the very high value obtained just at the beginning of the deceleration is neglected. Expressed otherwise, the friction as obtained by the accelerometer is about three-fifths of that indicated by motoring with the dynamometer.

Figs. 19 and 20 illustrate two tests taken under nearly identical conditions except that the leanest possible carbureter metering-orifice was used and the fuel was shut off at the beginning of the deceleration, in the former; whereas, in the latter, the richest possible adjustment was used and the fuel was not shut off. Slightly lower friction is shown by the dynamometer and slightly higher friction by the accelerometer in the first case than in the second, but the differences are not large enough to be significant. It is obvious that, as would be expected, no auto-ignition is shown in these tests, although both were operated at full load at 600 r.p.m. prior to the friction test.

The result of replacing the crankcase oil is shown in Fig. 21, the test represented having been made under conditions otherwise identical with those under which the data of Fig. 19 were obtained. The dynamometer

values in Fig. 21 are 30 to 40 per cent higher than those shown in Fig. 19, while the accelerometer values are 15 to 25 per cent higher.

Comparison of Figs. 21 and 22 shows slightly higher friction, as measured by the accelerometer, for the acceleration run than for the full-load run, just as is shown in Figs. 16 and 18. Presumably this is due to lower cylinder-wall temperatures in the acceleration run. This belief is supported by the fact that accelerometer values shown in Figs. 15 to 17—representing road load, acceleration, and full load at 300 r.p.m.—are all higher than those shown in Fig. 18, representing the full-load run at 600 r.p.m.

In all cases except those of acceleration runs, the accelerometer value of friction is seen to rise sharply at the highest speed; that is, just after the engine ceased firing. The cause of this is obscure and will be given further study.

The much higher dynamometer friction values shown in the last four charts are certainly due to the cooling of the cylinder walls during the time required to obtain dynamometer readings, especially since every change which tends to increase fluid friction results in increasing the disparity between values obtained by the dynamometer and those obtained by the accelerometer.

The lower accelerometer readings are substantiated in another way. If the dynamometer controls are set correctly, a friction reading at a definite speed can be obtained within 15 to 20 sec. after the ignition is shut off. If this and subsequent readings at short intervals are plotted against the elapsed time and the resulting curve is extrapolated to zero time, a much lower friction value is found than that normally obtained by motoring. In a series of tests on another engine, the zero-elapsed-time friction was only 80 per cent of that normally obtained by motoring.

From these tests, therefore, the following conclusions are drawn:

(1) Engine friction as measured by motoring does not necessarily represent the operating friction, the disparity increasing with increasing oil viscosity.

(2) Engine friction as measured by an accelerometer represents more nearly the friction under operating conditions, differing from the dynamometer values in the right direction and by approximately the right amount.

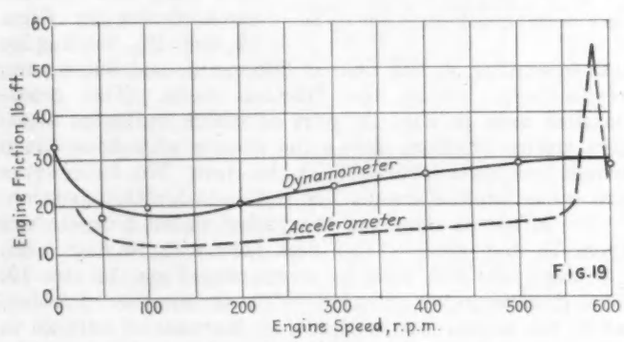
(3) At the same speed and the same temperatures of jacket water, oil and inlet manifold, the full-throttle engine-friction varies with the cylinder-wall temperature resulting from the conditions of operation. At high jacket temperatures, however, this variation is slight.

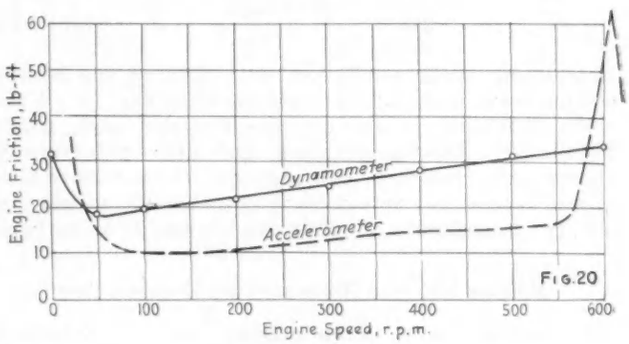
THE DISCUSSION

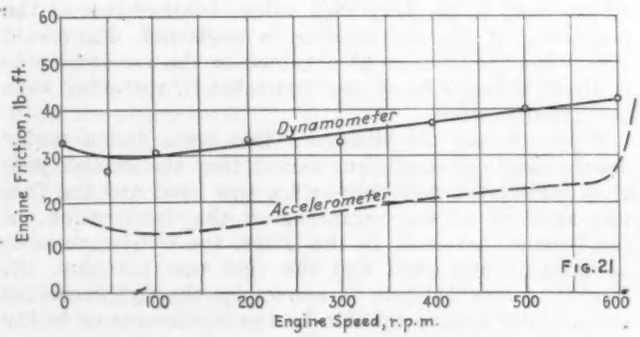
CHAIRMAN NEIL MACCOULL[9]:—This work has been done with the most accurate means of measuring ac-

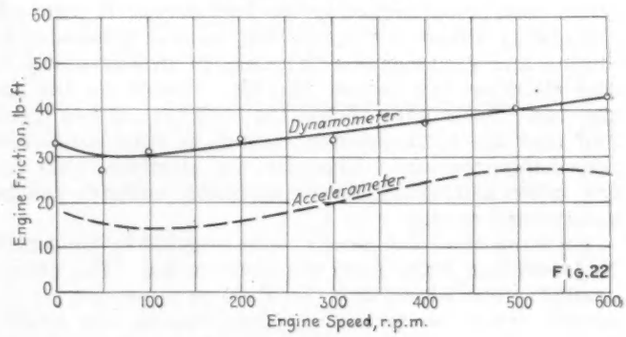
(*Concluded on p.* 141)

[9] M.S.A.E.—Automotive engineer, The Texas Co., New York City.









COMPARISON OF FRICTION TESTS WITH LOW WATER-TEMPERATURE

TEST CONDITIONS, FIGS. 19 TO 22

Fig.	Jacket-Water Temperature, Deg. Cent.	Jacket-Water Temperature, Deg. Fahr.	Manifold Temperature, Deg. Cent.	Manifold Temperature, Deg. Fahr.	Oil Temperature, Deg. Cent.	Oil Temperature, Deg. Fahr.	Mixture	Previous Loads
19	10	50	77	170.6	44	111.2	Full Lean	Full Load at 600 r.p.m.
20	10	50	74	165.2	28	82.4	Full Rich	Full Load at 600 r.p.m.
21	10	50	74	165.2	25	77	Full Lean	Full Load at 600 r.p.m.
22	10	50	79	174.2	25	77	Full Lean	Acceleration

Volatility Data on Natural Gasoline and Blended Fuels[1]

By OSCAR C. BRIDGEMAN[2]

SEMI-ANNUAL MEETING PAPER — *Illustrated with* CHARTS

THE extension of the equilibrium-air-distillation work of the Bureau of Standards to more volatile fuels, requiring measurements at temperatures considerably below 0 deg. cent. (32 deg. fahr.) has shown that the general relations deduced from the previous work are equally applicable to natural gasoline and to straight-run aviation-fuels and to natural-gasoline motor-fuel blends. Data are presented on three ethyl-ether blends with gasoline which give information on the amounts of ether to be added to gasoline for starting motor-vehicle or airplane engines at various temperatures. For comparison, data on two benzene-blends are reproduced from a previous report. A study of the entire mass of volatility data has indicated certain trends of the temperature ratios with the slope of the A.S.T.M. curve and with temperature. A more accurate correlation of all of the equilibrium-air-distillation (E.A.D.) results will be presented shortly, which will take account of the effect of these variables on the temperature ratios.

IN previous reports[3] to the Society on the cooperative fuel-volatility work, equilibrium-air-distillation data were presented for 25 gasolines. These data were obtained by experimentation with the Sligh apparatus at temperatures above 0 deg. cent. (32 deg. fahr.) and covered a considerable diversity of motor fuels. Recently there have appeared on the market a number of natural-gasoline fuels which are much more volatile than those previously investigated and hence require measurements at temperatures below 0 deg. cent. The present report deals with this sub-zero work, and includes volatility data on natural-gasoline blends, on natural-gasoline aviation-fuels and on blends with ethyl ether. The results on these fuels are in good agreement with the relations previously obtained for less volatile fuels.

Volatility as used in connection with the equilibrium-air-distillation work is defined as the temperature at which a given mixture of air and fuel vapor will be formed under equilibrium conditions at a pressure of one atmosphere from any mixture of liquid fuel and air supplied when a given percentage is evaporated. Accordingly, the lower the temperature corresponding to these conditions is, the more volatile is the fuel. The type of apparatus and the method used for measuring the volatility of fuels has already been described in detail[4].

For the work below 0 deg. cent. (32 deg. fahr.), the Sligh apparatus was fitted with a carbon-dioxide expansion-coil, and the bath liquid was a mixture in equal parts of carbon tetrachloride and gasoline (60 deg./60 deg. specific-gravity = 0.720)[5]. The temperature was automatically controlled at each point by means of a mercury-in-glass thermo-regulator, the excess cooling by the carbon dioxide being compensated for by the addition of electrical energy. Greater precautions were necessary in drying the air flowing through the apparatus to avoid formation of ice in the vaporization coil. In addition to a calcium-chloride tower, a drying tube immersed in a bath filled either with carbon-dioxide slush or liquid air was used for this purpose, depending upon the supply of these refrigerants available at the time. After being dried, the air was heated to about room temperature before passing into the flow meter, and was then precooled before passing into the vaporization coil. The gasoline feed was by plunger displacement controlled by a calibrated clock, as used previously, and for each rate of feed the weight of the plunger was adjusted by means of lead shot so that no change in the clock rate occurred with depth of immersion in the gasoline.

Calibration of the Sligh Apparatus

The degree of vaporization under flow conditions is a function not only of the thermodynamic system and the rate of flow but also, in general, a function of the characteristics of the specific apparatus used. Hence, for vaporization data by a dynamic method to be general and a function of the thermodynamic system only, it is necessary that the apparatus be calibrated to evaluate the effect of the rate of flow on the measurements. With a well-designed apparatus, carefully manipulated, the amount of liquid evaporated into the airstream from a constant air-fuel mixture will vary continuously with the rate of flow through the vaporization coil, and the change in the amount evaporated with rate of flow will become successively less as the flow decreases.

The value approached with each constant mixture and temperature as the rate of flow becomes zero is defined here as the equilibrium percentage evaporated, and if the percentages evaporated are measured for a number of sufficiently slow rates, which are determined by the particular apparatus, the extrapolated value at

[1] Published by permission of the Director of the Bureau of Standards, City of Washington.
[2] Research associate, Bureau of Standards, City of Washington.
[3] See S.A.E. JOURNAL, April, 1928, p. 437; see also November, 1928, Appendix 2, p. 488.
[4] See S.A.E. JOURNAL, April, 1928, p. 437.
[5] See International Critical Tables, McGraw-Hill Co., New York City, 1926, vol. 1, p. 61.

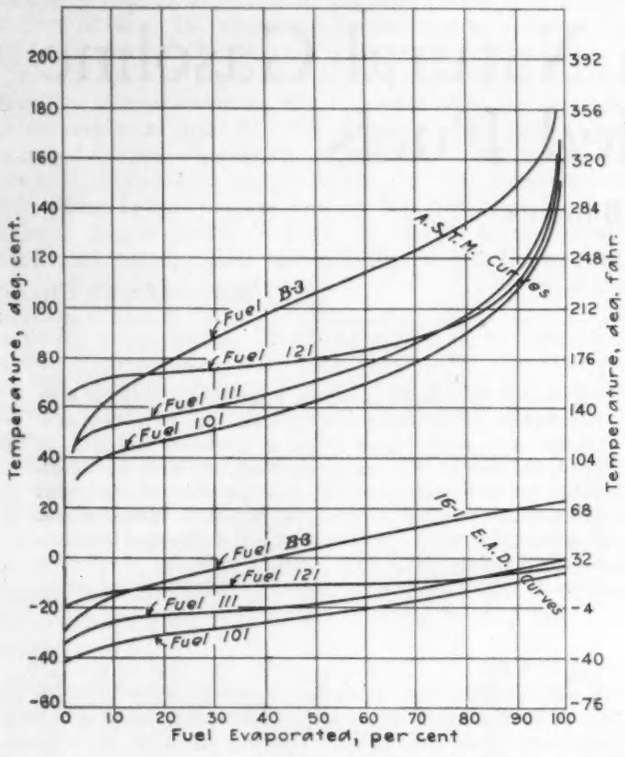


FIG. 1—CURVES FOR 16-1 RESULTANT AIR-VAPOR MIXTURES OBTAINED WITH FOUR AVIATION FUELS

A.S.T.M. Curves, Corrected for Distillation Loss, Are Also Shown for Comparative Purposes

zero rate of flow is independent of the apparatus and represents the equilibrium value for vaporization from the specific mixture being studied at the specific temperature. Measurements with other mixtures and at a number of temperatures serve to establish the departure from equilibrium with this specific fuel under all conditions of use in the apparatus. Similar investigations with other fuels are necessary to determine whether a general relation for departure from equilibrium can be obtained which is independent of the particular fuel used.

In the previous work, experiments had been made with three gasolines, at three temperatures, using six supplied mixtures of air and fuel, and feeds of 1, 2, 3 and 4 ml. of gasoline per min. A study of these data showed that the departure from equilibrium vaporization was independent of the specific fuel, the temperature and the supplied mixture, and was dependent only upon the rate of feed and the percentage evaporated. The following relation was found to hold for all of the measurements:

$$P = P_o (1 + 0.0125 F) \qquad (1)$$

where P is the equilibrium percentage evaporated and P_o is the experimentally determined value at the feed F in milliliters per minute. However, no measurements had been made at temperatures below 0 deg. cent. (32 deg. fahr.), and it was considered advisable to check the validity of equation (1) at lower temperatures and with more volatile fuels. Accordingly, experiments were made with fuels *B3* and *111*, supplying four mixtures, 4-1, 8-1, 12-1 and 16-1, at each of four rates of feed, 1, 2, 3, and 4 ml. per min., and at each of four temperatures, 15, 0, —15 and —30 deg. cent. (59, 32, 5 and —22 deg. fahr.).

At every constant mixture and temperature the value of P was computed for each rate of feed by means of equation (1). If the equation held below 0 deg. cent., the value of P should be the same at each rate of feed, and this was found to be the case for all of the data with an average deviation of 1.0 per cent evaporated, which is about the limit of accuracy of the equilibrium-air-distillation apparatus. At small percentages evaporated, the departure from equilibrium vaporization is less than the average deviation from the equation, so that in this range at low temperatures the results indicate the degree of reproducibility of the measurements; namely, one unit in the percentage evaporated. It is concluded that equation (1) can be used as general for the evaluation of the departure from equilibrium vaporization in the Sligh apparatus used at the Bureau of Standards, and all results obtained in the present work were corrected to equilibrium values by means of this relation.

Equilibrium-Air-Distillation Results

Thirteen fuels, described in Table 1, were used in the experiments at temperatures below 0 deg. cent. These include one domestic-aviation and three natural-gasoline aviation fuels, six natural-gasoline motor-fuel blends prepared by the Shell Petroleum Corp., and three blends with ethyl ether. For comparison, data on a motor gasoline and two blends with benzene are reproduced from a previous report[6]. Specification data on these fuels are given in Table 2. In making the

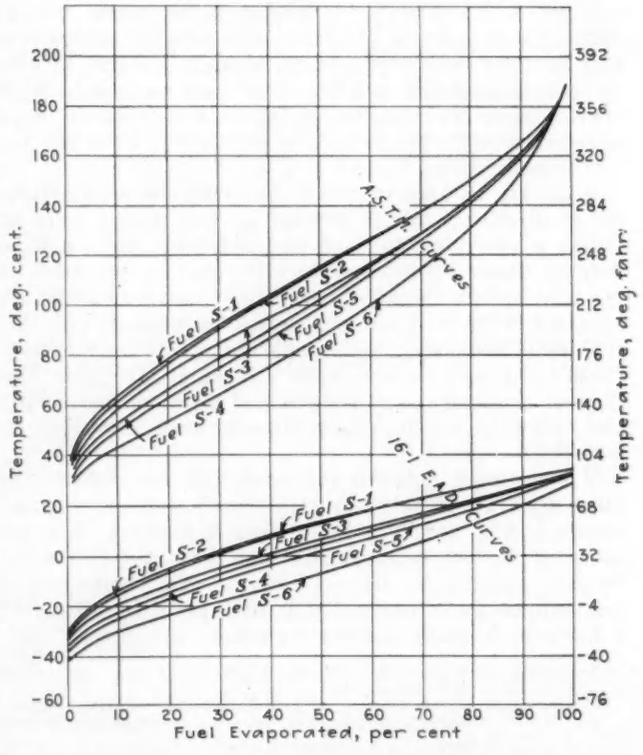


FIG. 2—COMPARISON OF THE RESULTS FOR THE SIX NATURAL-GASOLINE BLENDS

[6] See S.A.E. JOURNAL, November, 1928, Appendix 2, p. 488.

TABLE 1—DESCRIPTION OF FUELS

Fuel	Source	Remarks
B3	Army Air Corps	Domestic aviation-gasoline
101	Naturaline Co. of America	Natural-gasoline aviation-fuel
111	Phillips Petroleum Co.	
121	Virginian Gasoline & Oil Co.	
S1	Shell Petroleum Corp.	12 per cent natural gasoline in 375-deg. end-point cracked-gasoline
S2		16
S3		22
S4		26
S5		32
S6		52
EB1	Bureau of Standards	25 per cent ethyl ether in fuel *B3*
EB2		50
EB3		75
A	Bureau of Standards	U. S. Motor gasoline
H	Bureau of Standards	20 per cent benzene in fuel *A*
I		40
Ethyl Ether, 97 per cent		Contains about 2 per cent of alcohol and 1 per cent of water as impurities

A.S.T.M. distillations, the condenser was maintained at 0 deg. cent. rather than at some point in the permissible range[7] of 0 to 4.5 deg. cent. (32 to 40 deg. fahr.), and the receiver was maintained at the same temperature within 1 deg. cent. (2 deg. fahr.) as that of the sample measured into the distillation flask.

The curves for 16-1 resultant air-vapor mixtures obtained with the four aviation-fuels are shown in Fig. 1 where, for comparison, the A.S.T.M. curves, corrected for distillation loss, are also included. It is to be noted that, at each per cent evaporated, the temperatures on the 16-1 lines are in the same order as the A.S.T.M. temperatures. At 10 per cent evaporated, a comparison of the curves for fuels *B3* and *121* shows that, whereas the A.S.T.M. temperatures differ by 7 deg. cent. (13 deg. fahr.), the equilibrium-air-distillation temperatures differ by only 1 deg. cent. on account of the difference in the slopes of the A.S.T.M. curves. This phenomenon is evident only when the slopes are markedly different.

A comparison of the results for the six natural-gasoline blends is made in Fig. 2. In each set of curves the fuels are in the order *S1* to *S6*, going from top to bottom. An increase in the natural-gasoline content from 12 per cent to 52 per cent decreases the 10-per cent E.A.D. temperature from —14 to —30 deg. cent. (+7 to —22 deg. fahr.), producing a corresponding increase in the ease of engine starting with these fuels.

The curves for the three ethyl-ether blends are shown in Fig. 3, together with those for fuel *B3* and pure ethyl ether. The predicted temperatures at which engine starting with these fuels should be fairly easy are shown in Table 3. These temperatures are based on the correlation of Cragoe and Eisinger[8] and presume that 7.5 per cent of the fuel is evaporated from a 1-1 supplied mixture, thereby enabling a start to be made in about 10 revolutions of the crankshaft. For comparison, the temperatures obtained by Robb[9] for starting airplane engines with similar mixtures are also included. With the gasoline and the 25-per cent ether blend, the temperatures predicted from the present work are somewhat more favorable, which may be partly attributable to differences in the gasolines used. Further, in the experiments of Robb, the engine presumably was started by swinging the propeller; whereas the conditions to which the present prediction is applicable would be more nearly met by motoring the engine or by the use of an inertia starter.

TABLE 3—ENGINE-STARTING TEMPERATURES WITH ETHER BLENDS

Fuel	Bureau of Standards Engine Temperature, Predicted		Robb Engine Temperature, Observed	
	Deg. Cent.	Deg. Fahr.	Deg. Cent.	Deg. Fahr.
Aviation Gasoline	—15	5	— 7	20
25-Per Cent Ether-Blend	—28	—18	—18	0
50-Per Cent Ether-Blend	—32	—26	—34	—30
75-Per Cent Ether-Blend	—35	—31	..	..
Ethyl Ether	—38	—36	—39	—37

Fig. 4 shows the results on the benzene blends, the data being taken from a previous report. For comparison, the lines for pure benzene are also included. Be-

[7] See United States Government Master Specification for Lubricants and Liquid Fuels, Bureau of Mines Technical Paper No. 323B, 1927, p. 49.
[8] See S.A.E. JOURNAL, March, 1927, p. 353.
[9] See *Aeronautical Journal*, September, 1922, p. 374.

TABLE 2—SPECIFICATION DATA FOR FUELS

Fuel	Distillation Temperatures: Initial Boiling-Point, Deg. Cent.	Initial Boiling-Point, Deg. Fahr.	20 Per Cent, Deg. Cent.	20 Per Cent, Deg. Fahr.	50 Per Cent, Deg. Cent.	50 Per Cent, Deg. Fahr.	90 Per Cent, Deg. Cent.	90 Per Cent, Deg. Fahr.	End-Point, Deg. Cent.	End-Point, Deg. Fahr.	60 Deg./60 Deg Specific Gravity	Loss, Per Cent	Residue, Per Cent
B3	41	106	79	174	107	225	150	302	180	356	0.709	1.6	1.2
101	31	88	47	116	63	145	112	234	152	306	0.678	2.3	1.2
111	43	109	56	133	71	160	118	244	162	324	0.684	1.7	1.3
121	65	149	74	165	79	174	111	232	168	334	0.696	1.1	1.4
S1	38	100	79	174	117	243	166	331	190	374	0.743	0.8	1.2
S2	36	97	78	172	115	239	167	333	190	374	0.735	0.8	1.2
S3	38	100	75	167	107	225	165	329	190	374	0.731	1.4	1.1
S4	34	93	67	153	105	221	164	327	191	376	0.725	1.3	1.2
S5	31	88	64	147	100	212	162	324	191	376	0.719	1.3	1.2
S6	29	84	54	129	87	189	158	316	188	370	0.708	1.2	1.3
EB1	34	93	53	127	85	185	131	269	150	302	0.714	1.9	1.1
EB2	34	93	43	109	54	129	127	261	150	302	0.718	1.9	1.1
EB3	33	91	37	99	41	106	120	248	147	297	0.722	2.4	0.8
A	38	100	100	212	136	277	199	390	220	428	0.768	1.2	1.3
H	47	116	88	190	115	239	191	376	213	415	0.776	1.8	1.2
I	56	133	83	181	95	203	183	361	210	410	0.805	1.7	1.3

TABLE 4—TEMPERATURE RATIOS, T_{ASTM}/T_{16}

Fuel	Percentage 10	20	30	40	50	60	70	80	90
B3	1.31	1.33	1.34	1.35	1.36	1.37	1.38	1.41	1.44
101	1.32	1.32	1.33	1.33	1.34	1.35	1.37	1.40	1.44
111	1.32	1.32	1.33	1.33	1.35	1.36	1.38	1.41	1.45
121	1.33	1.33	1.34	1.34	1.34	1.35	1.36	1.38	1.42
S1	1.31	1.32	1.34	1.34	1.36	1.37	1.39	1.41	1.44
S2	1.31	1.32	1.33	1.35	1.36	1.38	1.39	1.42	1.44
S3	1.31	1.32	1.33	1.34	1.35	1.37	1.39	1.41	1.44
S4	1.31	1.32	1.33	1.34	1.36	1.37	1.39	1.42	1.45
S5	1.31	1.31	1.32	1.34	1.36	1.37	1.39	1.41	1.45
S6	1.31	1.31	1.33	1.34	1.35	1.37	1.39	1.42	1.46
EB1	1.31	1.32	1.32	1.34	1.36	1.38	1.39	1.40	1.43
EB2	1.32	1.32	1.32	1.33	1.34	1.35	1.39	1.42	1.44
EB3	1.32	1.32	1.32	1.33	1.33	1.34	1.34	1.37	1.46
A	1.31	1.33	1.34	1.35	1.37	1.38	1.40	1.42	1.46
H	1.32	1.33	1.33	1.33	1.35	1.37	1.39	1.42	1.46
I	1.33	1.33	1.34	1.35	1.35	1.36	1.38	1.42	1.47
Average	1.316	1.322	1.331	1.339	1.352	1.365	1.383	1.409	1.448
Previous Ratio	1.304	1.330	1.345	1.359	1.369	1.374	1.388	1.410	1.451

cause of the high 10-per cent point of fuel *A*, the usual decrease in ease of starting caused by the addition of benzene is not evident.

For all of these curves excepting those for the ether blends, the temperatures at 0 per cent evaporated were computed from the 10-per cent A.S.T.M. temperatures by means of relations which will be presented in a later report. The values for the ether blends were obtained by interpolation between those for fuel *B3* and for pure ethyl ether.

Temperature Ratios

The equilibrium-air-distillation data in the previous reports[10] were presented in the form of ratios of the A.S.T.M. temperatures in degrees absolute to the E.A.D. temperatures in degrees absolute corresponding to various resultant air-vapor mixtures at common percentages evaporated. Similar ratios were obtained from the present experimental data and are given in Table 4 for a 16-1 resultant air-vapor mixture. The ratios for fuel *A* and the two benzene-blends *H* and *I* show minor changes from those previously reported[11], due to a knowledge of the intercept at 0 per cent evaporated and to an improved method of obtaining the 16-1 resultant-mixture lines from the observed measurements.

Considering the diversity of samples, the ratios at each percentage evaporated are very constant and the averages are in good agreement with those previously obtained for the work above 0 deg. cent. The ether

[10] See S.A.E. JOURNAL, April, 1928, p. 437; see also November, 1928, Appendix 2, p. 488.

[11] See S.A.E. JOURNAL, 1928, Appendix 2, p. 488.

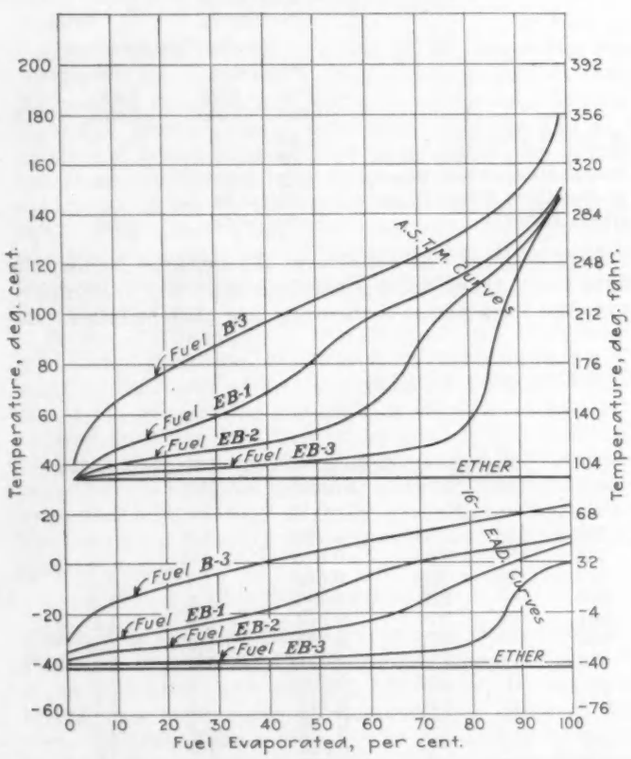


FIG. 3—CURVES FOR THE THREE ETHYL-ETHER BLENDS COMPARED WITH THOSE FOR FUEL *B3* AND PURE ETHYL ETHER

The Predicted Temperatures at Which Engine Starting with the Fuels Should Be Fairly Easy Are Shown in Table 3

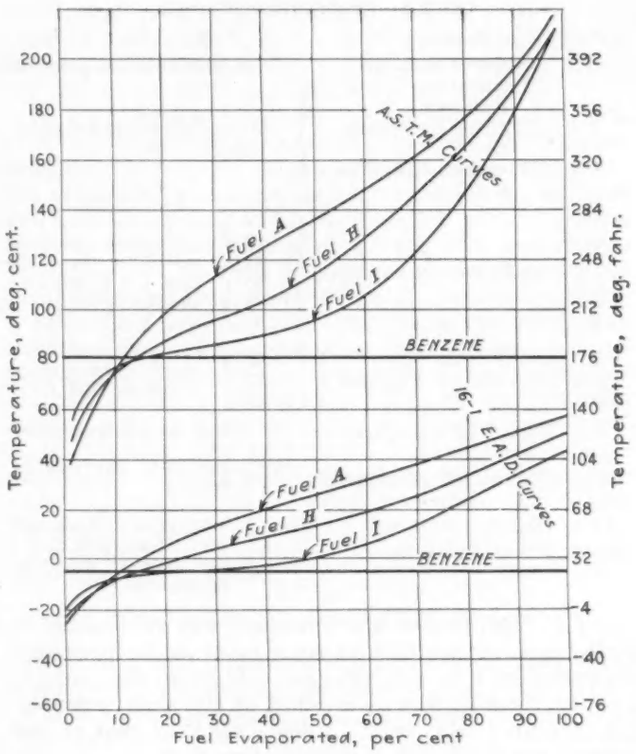


FIG. 4—CURVES OBTAINED WHEN USING THE BENZENE BLENDS COMPARED WITH THE LINES FOR PURE BENZENE AND FUEL *A*

TABLE 5—DEW-POINT DATA FOR 16-1 MIXTURES

Fuel	Dew-Point Deg. Cent.	Dew-Point Deg. Fahr.	90-Per Cent Point Deg. Cent.	90-Per Cent Point Deg. Fahr.	$T_{90\ Per\ Cent\ ASTM}/T_{DP_{16}}$
B3	24	75	148	296	1.418
101	−4	25	106	223	1.409
111	1	34	115	239	1.416
121	−1	30	110	230	1.408
S1	35	95	165	329	1.422
S2	35	95	166	331	1.425
S3	34	93	161	322	1.414
S4	33	91	161	322	1.418
S5	31	88	159	318	1.421
S6	28	82	154	309	1.419
EB1	10	50	128	262	1.417
EB2	8	46	124	255	1.413
EB3	0	32	112	234	1.410
A	56	133	196	385	1.426
H	50	122	186	367	1.421
I	44	111	177	351	1.420
				Average =	1.417
				Average △ =	0.004

blends show a somewhat greater deviation from the average than do the other fuels, but it is interesting that the disagreement is not very marked. The variations in the ratios seem to be attributable in part to differences in the slopes of the A.S.T.M. distillation curves and in part to a variation of the ratios with temperature. A consideration of the effect of these two variables will be undertaken in a later report.

The values of the temperature ratios for 8-1, 12-1 and 20-1 resultant air-vapor mixtures are in excellent agreement with values computed from the 16-1 ratios by means of the relations previously found, namely

$$R_{16} = 0.987\,R_{20} = 1.015\,R_{12} = 1.037\,R_8$$

The dew-points of 16-1 mixtures of these fuels with air were obtained by extrapolation of the equilibrium-air-distillation lines to 100 per cent evaporated. These data are given in Table 5, together with the corresponding 90-per cent A.S.T.M. temperatures corrected for loss. The ratios $T_{90\ per\ cent\ A.S.T.M.}/T_{DP_{16}}$ are very constant and the average is identical with the previous value[12].

[12] See S.A.E. JOURNAL, November, 1928, Equation (2), p. 484.

Operating Factors and Engine Acceleration

(*Concluded from page* 136)

celeration that I know of, one that has been developed by a long period of hard work.

MAURICE J. ZUCROW[10]:—Has anyone tried to find how much of the engine friction is due to the difference in load on the bearings because of differences in the pressure in the cylinders?

DONALD B. BROOKS:—A paper[11] was given at the Summer Meeting of the Society by S. W. Sparrow and myself which showed little difference in the oil-flow to the bearings according to whether or not they are loaded. Tests in which the cylinders were cut out successively have been made at an automotive research laboratory. The torque was measured under various conditions. These tests failed to check the friction as ordinarily measured with that determined by cutting out one cylinder at a time.

LESTER A. GARRARD[12]:—What kind of throttle was used in these tests? Was any consideration given to the lag of fuel on the walls of the manifold, which might account for some of the discrepancies? Were the cylinders that were not firing, during the tests of cylinders in pairs, stopped off?

MR. BROOKS:—A commercial carbureter was used, with a butterfly throttle. The only change in the carbureter was that the accelerating well and the economizer were not in operation. The electrically operated throttle-opening device was described in my Semi-Annual Meeting paper[13] to which reference has been made. The time for fully opening the throttle was 0.19 sec., but the throttle was opened wide enough in 0.10 sec. for the engine to develop 90 per cent of its full power at 300 r.p.m.

The liquid on the walls of the inlet-pipe was studied briefly in my preceding paper[13]. It seemed that the fuel flowing up the manifold reached the cylinder ports in appreciable quantities in about 3 sec. after the throttle was opened, under the conditions of these tests. Doubtless the time would vary with conditions, principally with the ratio between air and fuel. Under these conditions, a film thickness of about 0.1 mm. (0.004 in.) was accumulated in the manifold before fuel reached the cylinders.

During the tests with only two cylinders firing, the ignition of the other four cylinders was simply grounded. It would have required considerable time to stop off the cylinders between runs; and it was essential that successive runs be made at the same time-intervals, which were fixed by trial as 3 min., to give the most reliable results.

[10] M.S.A.E.—Research associate, Purdue University, Lafayette, Ind.

[11] See THE JOURNAL, August, 1927, p. 127.

[12] F.M.S.A.E.—Sales engineer, Standard Oil Co. of New York, Manila, P. I.

[13] See THE JOURNAL, September, 1928, p. 235.

Poppet Exhaust-Valve Design

By Richard E. Bissell[1] and Gordon T. Williams[2]

Buffalo Section Paper — *Illustrated with* Drawings

DESIGN and the material used in the construction of automotive poppet valves, particularly exhaus valves, are discussed in connection with the necessity of resistance of the valves to physical and chemical actions of wide variety. The problem of resisting these actions lends itself to mechanical and metallurgical solution. Each part of the valve—the head, the stem, and the end and tip of the stem—is discussed separately; and the design of the head is considered as it relates to the upper or combustion-chamber surface, the edge, the seat and the lower or manifold-radius portion. Provisions made for the grinding-in of the valves are shown and described.

Methods employed for maintaining the valves sufficiently cool to avoid excessive warping, pitting, scoring and the like include providing an ample valve-seat, designing the gas passage under the valve-head as nearly streamline as possible, making the valve-stem of large enough diameter to conduct the heat away rapidly, making the stem hollow and inserting cooling solution or a solid that melts at normal engine-operating temperature, inserting a high-conductive rod or tube core in the stem, and valve-guide design and bronze guides to conduct the heat away.

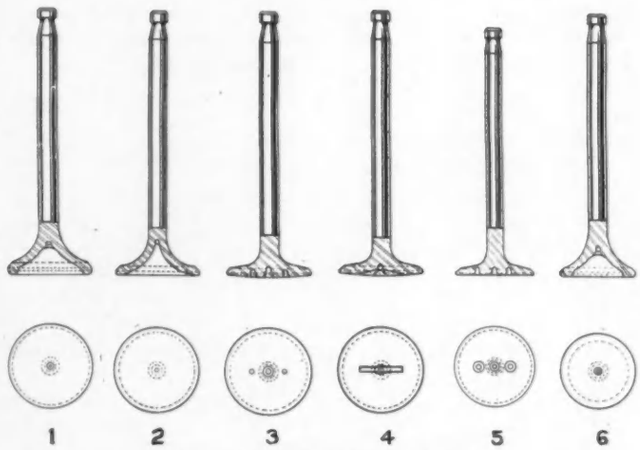
Special alloy metals are used as valve-insert materials to counteract stem expansion and maintain constant clearance with the tappet, and as caps or inserts for the stem tips to resist the effects of heat and hammering.

The dicussion covers a wide range of related subjects, such as the effect of the use of ethyl gasoline, the best steel to use for valves, reason for the high cost of airplane-engine valves, lubrication of the stem, valve springs and their effect, gumming and sticking, distortion of the cylinder-block, materials used for inserted valve-seats, and so forth.

THE automotive poppet valve, and in particular the exhaust valve, has to resist physical and chemical actions of wide variety and varying magnitude. The design, the material, and the relation with other parts of the assembly in which it forms an important part are worthy of study. The problem of resisting these actions lends itself to mechanical and metallurgical solution.

In calling attention to some phases of the mechanical solution, the valve is referred to as an integral assembly of its several portions—the head, the stem, the stem end and the tip—each with a distinct duty to perform and each requiring consideration before the assembly can operate satisfactorily. The design of the valve-head may be subdivided again into the upper or combustion-chamber surface, the cylindrical edge above the seat, the seat, and the lower or manifold-radius portion. The tendency of upper head-surface design has been toward the tulip or lily-cup type of concave surface shown in Figs. 1 and 2, from the convex surface illustrated in Figs. 3 and 4, and through the flat or plane-surface-type stage seen in Fig. 5. This is due, in a measure, to the fact that many convex-head valves reversed in service, in the manner of umbrellas. Hence those designers who found that the original shapes changed thought it a good plan to begin by imitating the resultant shape and to observe what would happen. They discovered that heated metal apparently resisted, without distortion, tensile stresses much better than transverse stresses and that, moreover, the resultant valve usually operated at a lower temperature, particularly on the stem section. Many tests indicated also an increase in obtainable horsepower, due either to the possibility of increasing compression without detonation resulting from overheated valve surfaces or to avoidance of eddy currents on the manifold-radius section. On their exit rush, the burning gases did not sweep the whole head surface but left in the center of the concave area a more or less inert-gas layer which retarded the absorption of heat by that surface.

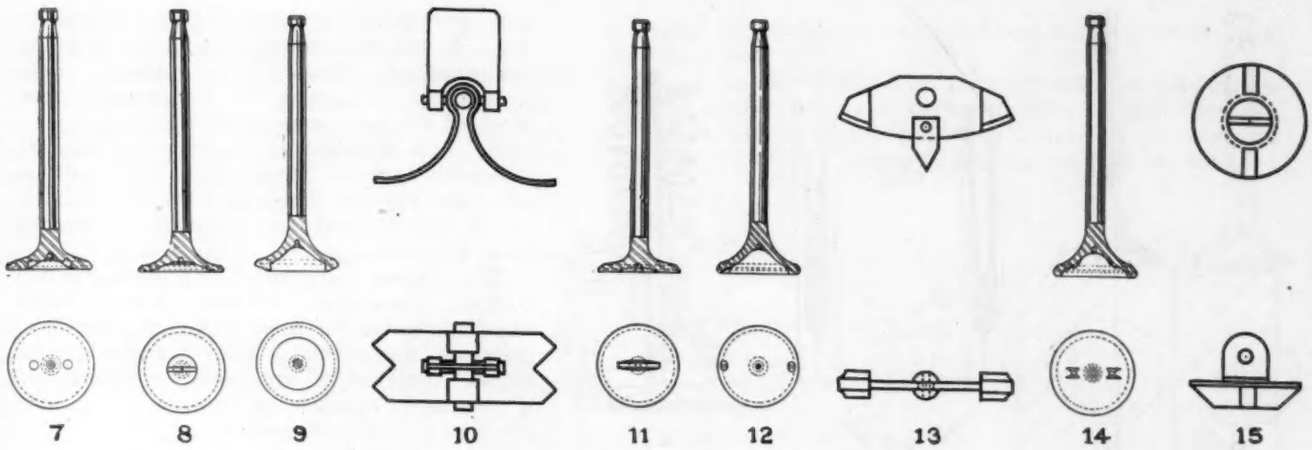
To increase the stability of the valve still further, a reinforcing-ring was placed above the seat of streamline surface. This reinforcing-ring prevented buckling, warping or curling, by both increased rigidity and increased circumferential conductivity that tended to equalize high local temperatures at any one portion of the valve periphery. (See Figs. 1 and 6.)



Valve-Head-Surface Designs

Figs. 1 and 2—Cupped Types. Figs. 3 and 4—Convex Types. Fig. 5—Plane-Surface Type. Fig. 6—Valve with Reinforcing Ring

[1] Chief engineer, Thompson Products, Inc., Cleveland.
[2] Assistant metallurgist, Thompson Products, Cleveland.



PROVISIONS FOR THE GRINDING-IN OF CUPPED-HEAD VALVES

Fig. 7—Cupped Head with Spanner Holes. Fig. 8—Cupped Head with Screw-Driver Slot. Fig. 9—Valve Designed for Grinding-In with a Special Spring-Tool. Fig. 10—Spring Tool for Grinding-In Valve in Fig. 9. Fig. 11—Head with Rounded-Edge Slot. Fig. 12—Valve with Special Type of Rim Slots for Grinding-In. Fig. 13—Tool for Grinding-In Valve in Fig. 12. Fig. 14—Valve Surface with Forged Lugs. Fig. 15—Grinding Tool for Valve in Fig. 14.

It was difficult to place provisions for valve grinding-in, such as screw-driver slots or spanner holes, in this concave surface, as is shown in Figs. 7 and 8.

The sharp edges were undesirable from the standpoint of detonating. Attempts to overcome this difficulty have resulted in many valve surfaces free of all such sharp corners or edges, special means being adopted for grinding-in, such as the use of rubber suction-cups, stem-gripping collets or spring-gripping tools (Figs. 9 and 10). Rounded-edge slots and holes of special type as shown in Figs. 11, 12 and 13, are used, as are also, in a few cases, upper surfaces with forged lugs designed to fit a special valve-grind-in device, as in Figs. 14 and 15.

As valves increase in size, head design becomes more important, since the maximum distance through which heat must be transmitted to the cooling media is necessarily greater, so that greater valve-head temperatures result. Fig. 16 shows a construction in which a special-alloy disc of high expansion-coefficient is inclosed in the head. Expansion of this disc due to increasing temperature shortens the valve, thereby counteracting stem expansion and maintaining constant clearance with the tappet.

TABLE 1—RECOMMENDED SEAT-WIDTHS FOR GIVEN PORT DIAMETERS, IN.

Port	Seat	Port	Seat	Port	Seat
7/8	5/64	2 3/8	5/32	3 3/4	9/32
1	5/64	2 1/2	5/32	3 7/8	9/32
1 1/8	5/64	2 5/8	5/32	4	9/32
1 1/4	3/32	2 3/4	5/32	4 1/8	5/16
1 3/8	3/32	2 7/8	5/32	4 1/4	5/16
1 1/2	3/32	3	7/32	4 3/8	5/16
1 5/8	3/32	3 1/8	7/32	4 1/2	11/32
1 3/4	3/32	3 1/4	7/32	4 5/8	11/32
1 7/8	3/32	3 3/8	1/4	4 3/4	11/32
2	1/8	3 1/2	1/4	4 7/8	3/8
2 1/8	1/8	3 5/8	1/4	5	3/8
2 1/4	1/8				

Fig. 16—Valve-Head with Inclosed Disc of Special Alloy

Valve-Seat Functions and Design

As the seat of the valve seals the cylinder, its conical sealing surface should at all times be unimpaired and of an angle tending neither to hold foreign matter in place nor to bind or wedge unduly. The conventional 45-deg. seat has much to recommend it for ordinary use, although for racing purposes a 30-deg. seat may prove more desirable, giving better opening for the same extent of valve lift.

While the valve-seat must have sufficient area to present ample surface to the cooler cylinder-seat and be wide enough to allow resurfacing of cylinder-seat and valve-seat, it must present no more surface to the exhaust gas than is absolutely necessary. In other words, the valve-seat surface should as far as possible be a useful cooling surface. Table 1 shows dimensions of recommended seats for ports of various diameters. Seat-width is measured in projection, rather than along the angular face.

Nature of cylinder-seat material, magnitude of the spring-pressure and the oil-passing nature of the lubricating system tend to influence valve-seat areas through tendencies to indenting, grooving or battering. These areas are also influenced by the nature of the fuel. Some doped fuels tend to deposit foreign matter which occasionally breaks or sloughs off locally, producing a flame opening, with the result of rapid erosion of the valve-seat.

As stated, the radius under the head should be as nearly as possible a streamline from the cylinder-seat to the exit port, so as to prevent eddy currents that might result in back pressure. It is important also that the radius be shaped so as to keep the valve-head most of the time in tension rather than in transverse stress, as the plastic flow or creeping of metals under heat appears greatest under conditions of transverse stress. The stresses are indicated in the diagrammatic sketch, Fig. 17.

It is desirable to polish the radius under the head to prevent

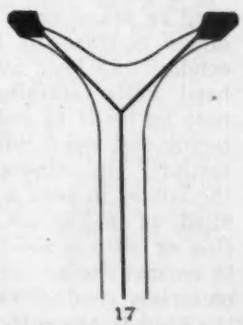
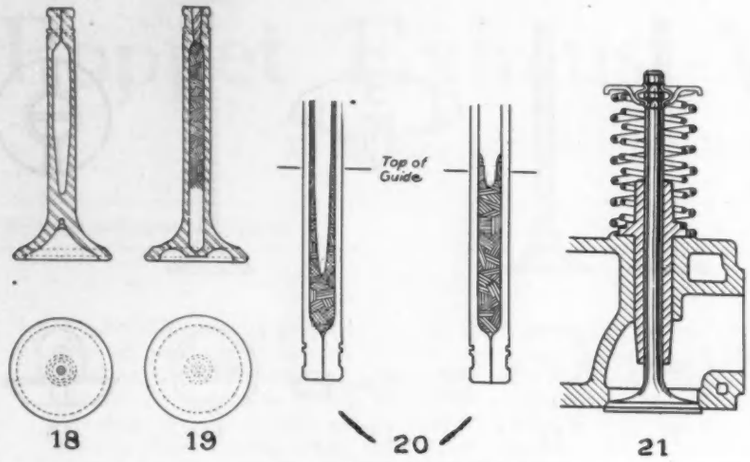


Fig. 17—Diagrammatic Sketch of Stresses in Valve-Head



VALVE-STEM DESIGNS

Fig. 18—Hollow-Stem Valve. Fig. 19—Salt-Filled Hollow Stem. Fig. 20—Comparison of Behavior of Salt-Filled Valve-Stems in Air-Cooled and Water-Cooled Engines. Fig. 21—Special Type of Lock-Seat Groove

the localization of high temperatures passing slightly raised surface-portions produced by very rough machining or grinding. A scaled surface, sometimes called forge-finish, cannot blend properly into the stem but leaves a hub or shoulder where the grinding of the stem ends. This condition localizes stresses and often results in fracture. It should perhaps be regarded as a problem to be solved metallurgically rather than as a design problem.

Valve-Stem Strength and Conductivity

The valve-stem must be of large enough diameter to conduct the heat from the head to the cooling media surrounding the guide. The stem should be of such section that it has sufficient strength, at the temperature of operation, to resist repeated stress caused by opening and closing of the valve at high speed. It must also be able to resist stresses produced by misalignment of valve-stem and valve-seat, either as originally set up or due to conditions caused by relative movement of the cylinder-seat and the valve-guide or by side pressure from cocked springs. A hollow-stem valve, as illustrated in Fig. 18, is used in many cases to present a larger surface to the guide to conduct the heat away from the head while retaining such lightness as tends to reduce seat-battering and wear. Sometimes, particularly in air-cooled engines, the hollow in such a valve-stem is filled, as in Fig. 19, with a solution or with a solid which melts in normal engine operation; these materials conduct the heat from the head to the colder portions of the stem, acting either as mechanical carriers or by vaporizing and recondensing. In water-cooled engines, salt-filling has comparatively little cooling value, as the guides are at such a low temperature that most of the salt remains solid during operation. This condition is illustrated in Fig. 20.

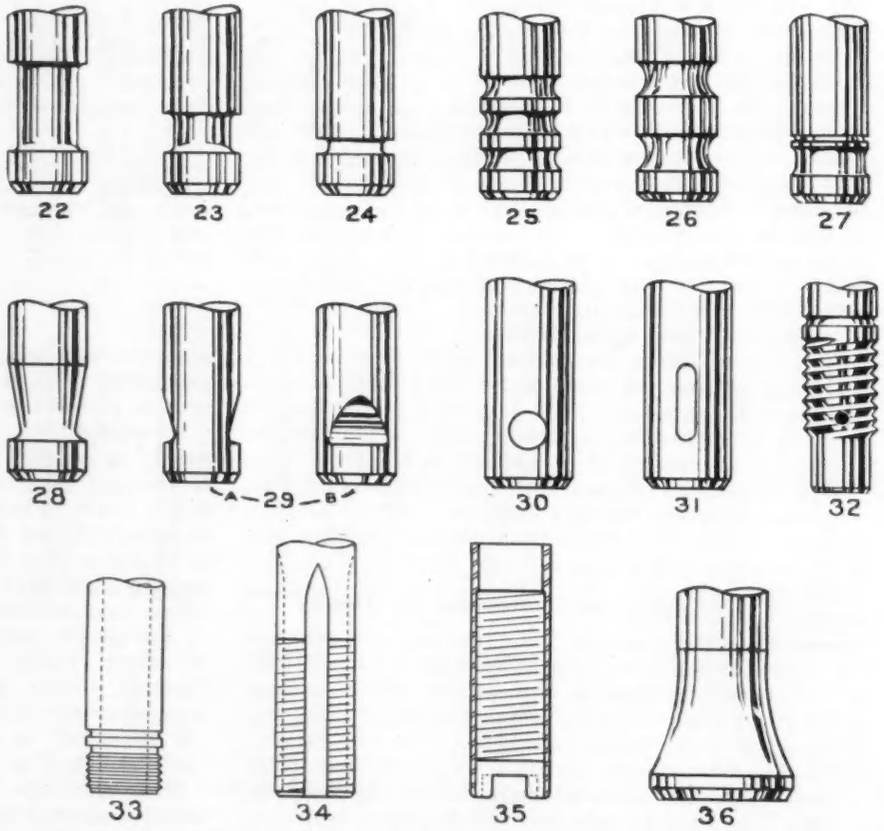
Applications for patent have been made on the valve designs shown in Figs. 5, 9, 11, 12, 14, 19 and 20; and the design in Fig. 21 has been patented.

The general recommendation is to provide 0.001-in. clearance between exhaust-valve stem and guide for each 0.1-in. of valve-stem diameter for normal steels; for steels with higher coefficient of expansion we recommend a clearance increase in proportion to the increase of the coefficient.

Guides and Spring-Lock Seats

Various valve-guides of special design and material are coming into use. Guides coming well up on the valve-stem tend to reduce valve-head temperatures, bronze guides conduct the heat faster than those of cast iron, and guides of appreciable thickness made with heavy reinforcing bell-rings at the top conduct the heat away rapidly and tend also to equalize non-symmetrical temperature conditions.

The valve-spring retainer-lock seat must have sufficient residual area at the base of the groove to withstand the spring pressure upon closing as well as the compressive effect of the opening forces; it must also be



FIGS. 22 TO 36—VARIOUS RETAINER-LOCK SEATS USED IN AUTOMOTIVE ENGINES

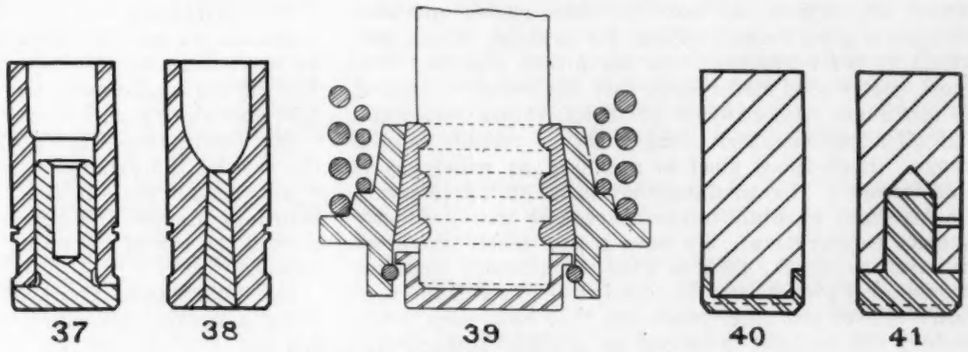
able to resist service stresses produced by insertion or removal of retainer locks and bending forces produced by angular rocker-arms or cocked springs. If possible, sharp corners are to be avoided, and sufficient areas of lock-seat surface should be provided to withstand impact without riveting and burring. Punched retainer-locks of the horseshoe type often give trouble due to the punched fin or burr being left on in a cyanide-hardened condition.

We recommend the form of lock-seat groove shown in Figs. 1 to 9 inclusive, typifying what we regard as good design practice for different head and stem types. As an alternative, however, another type shown in Fig. 21 is recommended to equalize spring pressure and prevent side-thrust resulting in stem wear. While effective in these respects, this design is at the same time relatively light in construction. Various types of retainer-lock seats are illustrated in Figs. 22 to 36 inclusive.

Tip Design and Construction

An important feature in the design of a valve is its tip, which should have sufficient area to withstand the action of the mechanism operating it, without being worn, battered or riveted. At the same time it should possess a surface normal to the center line of the valve-stem. The tip is usually chamfered to serve as a center when originally ground, and also to facilitate shipping without nicking or burring in service, which would prevent its removal from the guides. Since usually the tip face is of necessity very hard and the retainer lock, which is so near, must as a rule be tough, any slight increase in distance between the two allows heat-treatment of the one without compromise of and effect upon the other.

In the case of salt-filled valves, the tip contact-surface is usually made from different material than the body of the valve. In this case such designs as are shown in Figs. 37 and 38 are used, and are very satisfactory.



VALVE-TIP CONTACT-SURFACE DESIGNS

Figs. 37 and 38—Hollow-Stem Contact Surfaces of Different Metal than Valve Body.
Figs. 39 to 41—Protection of Soft Valve-Tips by a Cap or Plug

In foreign countries, where unhardenable steels such as the nickel-chromium variety are used, caps such as shown in Fig. 39 or 40 are placed over the tips, or plugs of the type illustrated in Fig. 41 are inserted in them. In this Country, few of these steels have been used because of steam galling and sticking tendencies; but where they are used, welding of other metals—either below the upper portion of the guide or at the immediate tip end—has been resorted to. However, the variable heat of welding, the intermediate unbroken sheets of high-alloy constituents and the human equation prevent this type of piece from proving as dependable in the same service as are solid pieces or pieces with push fits.

In all of the designs shown, the limits of eccentricity, of squareness, of taper, and of size should be specified, so that there will be no doubt in the mind of the manufacturer or user as to just what is required.

THE DISCUSSION

PETER MAXIMER[3]:—I have read a great deal about the effect of ethyl gasoline on various engines, but in all my experience have not met an instance of valve trouble that could be clearly charged to the use of ethyl fuel. I remember that C. F. Kettering mailed a letter to Buick distributors some time ago to the effect that the use of ethyl gasoline is as safe as that of any other. He mentioned the importance of proper push-rod clearance, but this holds true no matter what fuel is used. I have not found that a valve will scale due to the use of ethyl gasoline.

G. T. WILLIAMS:—When ethyl gasoline was first sold it attacked the valves very seriously. Later, it was withdrawn from the market, and when it reappeared its chemical analysis had been changed considerably, but the valves would still pit. During the last year, the ethyl gasoline has again been changed and today presents no problem. It forms a deposit but this is not harmful, except that it cracks off occasionally; if that happens on the valve-seat, it will give rise to burning but, generally speaking, ethyl gasoline is as satisfactory a fuel as anybody can use.

W. R. GORDON[4]:—The old cast-iron valve was a good valve, in its way. Recently we made some tests by heating the valves, checking them by the color test for temperature and with a scleroscope for hardness at different temperatures. The cast-iron valve retained its hardness up to a point of about 1400 deg. fahr. At higher temperatures the newer materials proved much superior. I am interested also in what Mr. Williams said about the bronze valve-guide. I have noticed, after running some of our engines for 100 hr. wide open, that the valves were in excellent condition.

Best Steels for Valves

MR. WILLIAMS:—Of course, any disadvantages of the dual valve are purely mechanical, consisting in a

[3] Service manager, Buick Branch, Buffalo.

[4] M.S.A.E.—Transportation engineer, Pierce-Arrow Motor Car Co., Buffalo, N. Y.

duplication of friction losses, of mechanisms, and the like. They also offer many advantages, if you can afford to use this dual mechanism. The only question is whether the expense is justified.

Without going into detail on the subject of steels, let me say that there are the simple steels such as, for example, carbon steels and the simpler S.A.E. steels, which are extensively used for inlet valves and also, though to a very small extent, for exhaust valves, particularly for replacement on low-priced engines. The most widely used material, in fact the world's standard, is silchrome, the analysis of which varies somewhat, but all silchrome steels come within a certain definite range. High-speed steel is not used as widely as it was formerly. Its advantage lay in its ability to retain its strength at high temperature. It was distinctly subject to corrosion. We have a new steel, which we call our C. N. S., that is very satisfactory and has shown good properties. It remains bright at 1800 deg. fahr. There are other materials that have very satisfactory characteristics in one or another respect, but this is not the whole story. Cast iron held its hardness but was very brittle, so that it would fail in about one-tenth the time an ordinary valve made of steel of present-day quality would in a modern engine. Certain special developments, such as chrominum-plated valves and valves surface-hardened with ammonia, are used to some extent. The latter may make possible the use of a cheaper steel. Whether such a valve may be used depends on conditions of operation.

MR. GORDON:—Silchrome steel has a smooth surface after the black test but cobalt-chromium steel is rough.

MR. WILLIAMS:—Exactly. Cobalt-chromium steel becomes rough, but silchrome steel has some self-lubricating properties; after continued operation it has a mirror-like surface.

GUSTAF CARVELLI[5]:—Are the high prices of airplane valves due to the small production?

Why Airplane-Engine Valves Cost More

MR. WILLIAMS:—Several phases are involved in the matter of cost. For example, a certain company builds about 200,000 cars a year. We make 12 times that number of valves for the company's original equipment; in addition we make about half that many for replacements. Orders on a valve such as yours are very much smaller, and some valve orders are for dozen lots.

With automobile valves we could take off all supervision and they would turn out all right; because of the great production we watch our valves very closely, and throw away many that you would accept but which we do not want to have out. Among other things, our microscopic inspection is responsible for the high cost of airplane valves. The manufacturing quantities and the very close limits also enter into the matter. Again, an automobile valve can be made almost entirely on automatic machines, but we cannot do that with airplane valves, because of the cupped head, for one reason. When we are held to very close limits on concentricity, we cannot roll-grind, as we can on automobile valves.

MR. CARVELLI:—Do you advocate the lubrication of exhaust-valve-stems with oil?

MR. WILLIAMS:—We have experimented with some of these new devices for upper cylinder-lubrication and have found that they increase valve life and, apparently, also increase the time between grinds.

JOHN V. COSTELLO[6]:—Are any manufacturers actually trying to lubricate the valve-stems? How does the lubricant get into the valve-guide?

MR. WILLIAMS:—It can be done in two ways: The vegetable oil used is either dissolved in the fuel or can be introduced by the use of an atomizer on a suction line off the intake manifold. The oil is introduced just fast enough to give lubrication.

MR. COSTELLO:—That does not work out very well in the case of the exhaust valve.

MR. WILLIAMS:—It does help the valve-guide, as it seems to prevent the gummy substance from forming around the top of the guide as well as providing lubrication.

MR. COSTELLO:—You spoke about the importance of using a square valve-stem end, yet a slightly rounded end has been used successfully.

MR. WILLIAMS:—Slightly rounded ends have been used to some extent at different times, but at present they are not used much. The principal difficulty has been to get contact so that there will be no side-thrust.

QUESTION:—Is there a chemical action which would cause pitting or cause the valves to stick when using an upper-cylinder lubricator?

MR. WILLIAMS:—Perhaps some oils on the market cause gumming but, so far as chemical action is concerned, we have found no such disadvantages.

Spring Effects and Valve-Seat Shape

W. E. JOHN[7]:—What effect has the spring load on the valve; first, as regards changing the shape of the seat and, second, distorting the valve itself?

MR. WILLIAMS:—The effects might be summarized as follows: The heavier the spring is the better the valve will stay seated. Of course, with a heavy spring, there is a tendency to battering at high temperatures, but with normal spring-pressures the net result is better seating.

MR. JOHN:—Spring manufacturers recommend light springs to prevent surge. We have on the block now an engine with light springs, which surge at about 1200 r.p.m., yet they do not seem to have done the valves any harm. Should valves rotate?

MR. WILLIAMS:—Rotation of the valve will give an improved seat, as every time it seats it is just as if the valve were being ground-in again; the tendency to a one-sided seat is lessened. The springs should be just right to make the valve-stem follow the cam at all times. The question of surge, I think, is a matter of cut and try.

MR. JOHN:—Do you recommend a flat-faced or a round-faced seat?

MR. WILLIAMS:—We recommend a flat seat rather than a round one, because it is easier to grind-in and to regrind.

MR. JOHN:—In the case of high-compression oil engines, operating at a working pressure up to 950 lb. and under the absolute necessity of a tight seat, would not a narrow seat be better than a wide one?

MR. WILLIAMS:—It certainly would be.

WILLIAM H. MACCOLLUM[8]:—What is the chief cause of sticking valves?

MR. WILLIAMS:—The two principal causes are gum

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[6] Curtiss Aeroplane & Motor Co., Inc., Buffalo.

[7] M.S.A.E.—Buffalo Gasoline Motor Co., Buffalo.

[8] Service manager, S. A. Stephens, Inc., Buffalo.

collecting on the valve-seat and galling in the guides, due to faulty design or to poor materials. I believe that any other cause of sticking would be a special case. Of course, the guide must not deform.

MR. MACCOLLUM:—Take the case of an automobile which has gone 3000 miles and develops sticking valves. After they are ground, the car will go for another 1000 miles, when the same trouble will recur, regardless of any kind of oiler put on the valve-guide.

MR. WILLIAMS:—I had not heard of such a case. Sticking is due, as I said, principally to freezing or to the gummy deposits that tend to hold the valves open. There is a possibility of the valve not moving straight up and down in the guides; it is possible to have sticking valves with 0.020 in. clearance, if it is not running true. A rocker-arm that is not pushing straight on the valve, or an improper valve tip, will cause it to stick. I do not know why sticking should continue after such conditions have been corrected.

MR. MACCOLLUM:—We have found that the upper-cylinder lubricators are of value, if it is desired to increase the engine speed for testing, but, as far as oiling the guides is concerned, they did no good.

MR. WILLIAMS:—We have found that the upper-cylinder lubricators apparently have a good effect.

MR. JOHN:—Do you not think that the design of the combustion-chamber and of the ports has something to do with the successful application of the upper-cylinder lubricator?

MR. WILLIAMS:—No doubt they do have.

MR. MACCOLLUM:—We have split the stems, reduced the length of the guides, sawed the guides full length, and renewed the guides and lifters, but still have not corrected the trouble. I think that expansion is causing it. However, when we use two cylinder-head gaskets, the trouble is eliminated.

Cylinder-Blocks Sometimes at Fault

MR. JOHN:—That sounds as if distortion of the block was the cause.

MR. WILLIAMS:—You might have the material in the block tested. I know of a manufacturer who had a great deal of trouble with the battering of the cylinder-block. On investigation, we found that the block was entirely too soft. The manufacturer said he knew it but could not afford to machine the block when the hardness is best for service. You might find that the blocks were distorted, causing the valve to stick in the guide. Or it might be a matter of the coefficient of expansion.

MR. MACCOLLUM:—When we reduced the engine-compression, the trouble disappeared.

ELWOOD T. LARKIN[9]:—I deeply sympathize with the valve maker. I believe that much of the engine trouble existing today is primarily up to the engine manufacturer. I do not think it is necessary to grind the valves very often. We issue instructions not to touch the valves for 100 hr. In marine work, we all know there is a certain amount of leakage past the pistons of a vapor which contains a percentage of water and some surphuric acid. The latter will attack valve-stems badly.

A MEMBER:—Is there any S.A.E. Specification covering variation in the straight up-and-down action of valve-springs?

MR. WILLIAMS:—I do not know of any.

A MEMBER:—Would not such a variation cause the valves to stick? Do you not think the manufacturer should be instructed to see that springs do not vary in this respect, before they are put into the engine?

MR. WILLIAMS:—That might not help, as springs are likely to change their shape after 5-hr. running.

Material for Inserted Seats

MR. JOHN:—What is the best metal to use for an inserted seat?

MR. WILLIAMS:—Of the two metals that we recommend—bronze and our C.N.S. steel—either works very well. But, in ordinary automobile practice, the cylinder material itself is satisfactory.

MR. JOHN:—Are bronze seats used in aluminum castings?

MR. WILLIAMS:—Yes.

MR. JOHN:—Do you recommend that they be threaded or pressed in?

MR. WILLIAMS:—We recommend that they be pressed in, when expansion characteristics permit, but they can be threaded in.

QUESTION:—Do you recommend the split guide?

MR. WILLIAMS:—The split guide is not as satisfactory as the straight guide.

QUESTION:—What are the particular characteristics of the Ford valve?

MR. WILLIAMS:—The Ford design, shown in Fig. 36, is patented, I understand, so that no one else can manufacture it. The design simplifies the retainer and a larger surface is presented for tip wear, but split guides are required. No provision is made for adjustment.

[9] Chief engineer, Sterling Engine Co., Buffalo.

Motor-Vehicle-Fleet Economics

By F. K. GLYNN[1]

DETROIT SECTION PAPER

Illustrated with PHOTOGRAPHS AND A CHART

THE TECHNICAL requirements of motor-vehicle-fleet operation are receiving increasing attention, according to the author, who analyzes two distinctly different plans for fleet organization; one, that of providing for sufficient man-power to care for all repairs, and the other, of later origin and requiring a much smaller organization, the delegation of all repairs to the specialists of the commercial repair-shops. In analyzing these plans he considers a fleet of 500 vehicles. His analysis of the latter plan has to do with a fleet organization having no shop personnel and a total of 10 or more vehicles per employe, the fundamental requirements in this case being the provision of qualified inspector-repairmen and efficient manufacturers' and commercial service-stations.

Concerning economical service life, the author states that no set rules have been found effective, but that it has been demonstrated that a critical point is reached in the life of each chassis beyond which it is uneconomical to make extensive repairs. This point is indicated when the cost of immediate repairs, plus the estimated running maintenance during the period of extended life of the unit is greater per mile, hour, ton-mile and the like, than the cost of running maintenance for the first-life period of a new chassis. In this consideration must be included the increased depreciation for the new chassis. The critical point for each class or make of chassis can be approximated from past records and, as each chassis approaches this point in service, consideration should be given to its replacement. Individual consideration of each chassis is stressed for the reason that, depending upon the driver's expertness, the territory covered and the work performed, some chassis will operate economically in excess of others, and therefore the calendar and the odometer are not conclusive evidence in chassis replacement.

Other subjects touched upon are chassis selection, body design and appearance, garaging facilities and operation, maintenance costs and quality measurement. In conclusion, the author solicits hearty cooperation between the manufacturers, the operators and the Society, so that the efficiency and utility of motor-vehicles can thereby be increased continuously.

In the discussion following the paper procedure regarding methods of accounting is outlined, as are also the practices relating to the determination of when to use solid, when to use cushion and when to use pneumatic tires. The subjects of maximum permissible gross load, records of tire performance, and the substitution of cushion, pneumatic and balloon tires on motor-trucks in place of solid tires are discussed, and methods of recording tire performance are outlined. The question as to what the manufacturers are doing to make service-station truck-repair costs more economical than in the small-fleet shop is debated.

A SUMMARY of the responsibilities of the man in charge of a fleet of motor-vehicles is presented in the accompanying box. We have heard much concerning the engineering involved in the design of automotive equipment, but little has been said of the increasing technical requirements in fleet operation. Some fleet operators have responsibilities in addition to those specified, but none in full executive charge of a fleet ordinarily would have less.

Two distinctly different plans can be followed in the formation of a fleet organization. Plan 1, shown as Table 1, comprises sufficient man-power to care for all repairs and has its advantages for certain fleets. Plan 2, of later origin and requiring a much smaller organization, shown as Table 2, proposes delegating all repairs to the specialists of the commercial repair-shops. Let us consider these plans as applied to a 500-vehicle fleet.

If a central repair-shop is maintained, Plan 1, it is logical to expect that minor repairs and the replacement of units will be included in the work of the scattered garages housing the fleet and that the operating supervisor would require approximately 1 inspector and 6 mechanics per 100 vehicles. These inspectors, responsible for the satisfactory operation of the vehicles, make periodic visits to each vehicle; they adjust carbureters, check valve-timing and the like, and note any repair work to be done by the garage mechanics or the repair shop. The shop supervisor, on a basis of one week's major-repair work per year per vehicle, would require about 5 working foremen, 30 mechanics, and 5 stockmen. One particular problem that confronts the fleet shop is the distribution of the work so that there will be a uniform load with minimum interference with the utility of the vehicles. In addition thereto, the supervision of the stockroom presents some difficulties in view of the human tendency to build up a stock of parts and supplies far in excess of vehicle requirements, thus causing attendant heavy carrying-charges.

Fundamentals of Plan 2

Plan 2 relates to a fleet organization that has no shop personnel and a total of 10 or more vehicles per employe, since 10 has proved to be a conservative figure, as a number of fleets are now operating successfully with as high as 18 vehicles per employe. The fundamental requirements of Plan 2 are (*a*) the employment of qualified inspector-repairmen and (*b*) the

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availability of efficient manufacturers' and commercial service-stations.

The driver of the vehicle is, in the last analysis, the one upon whom rests the greatest responsibility for the efficient operation of the vehicle and, sharing in this responsibility, the inspector-repairman or field-repairman in Plan 2 aids as the driver's first assistant in all matters concerning his vehicle by furnishing advice, inspection and repairs. He receives and satisfies the driver's reports of his mental and mechanical troubles to the end that the drivers follow his leadership toward safer and more efficient vehicle operation. Study indicates that an inspector-repairman can successfully cover between 50 and 75 vehicles each 5 to 7 weeks, depending upon the territory. During each visit to a vehicle he corrects all mechanical troubles within the scope of roadside repairs and orders the vehicle into a selected repair-shop for repair of the remainder.

Duties of a Superintendent of Transportation

Build up an efficient operating organization.

Determine the most efficient type, make and size of chassis, body, accessories and auxiliary equipment for the job.

Determine the economic time for replacement.

Arrange for the purchase of all automotive equipment, maintain an adequate stock of parts and supplies, and arrange for the disposal of replaced equipment.

Determine the practices to be followed in the daily maintenance and in the repair of the vehicles.

Locate, lay out, and equip garages and shops.

Collect, compile and study operating data to effect improvements and economies.

Measure operating results.

Study the use of the vehicles in the field with a view toward increased productivity and the elimination of lost time.

Determine the qualifications of the drivers and train them in the safe operation and efficient care of the vehicles.

Review proposed motor-vehicle laws.

Handle registrations and licenses.

The inspector-repairman's night garage-force consists of 1 mechanic, 1 washer and 1 garageman for each 50 vehicles. The mechanic confines his work to tinkering service-repairs and devotes the greater part of his time to following up the repair work being done during the night at the outside repair-shops. One washer, with adequate power-washing equipment, is expected to clean about eight vehicles per night, thereby washing each vehicle once each week. The garageman employed for gassing, oiling and greasing furnishes gasoline and oil to each vehicle each night and follows an approximate two-week schedule on greasing.

Regarding the second fundamental, (*b*), for successful operation without company-owned shops, in the larger centers manufacturers' service-stations and, in the small cities, authorized commercial service-stations are available. In view of the increasing responsibilities assumed by the manufacturers for the efficient operation of these shops, satisfactory service can usually be obtained.

Comparing the 500-vehicle-fleet shop with the outside shop, one source of economy should be found in the ability of the latter to secure greater production from the same investment in shop equipment. Both may need an investment of about $50,000 in shop equipment, with annual carrying charges of say $7,500; but, in the first case, this expense is spread over 500 vehicles and in the other case it may be distributed among 5000 vehicles. Also, the investment in parts at one location for 5000 vehicles would not approach 10 times that required in one 500-vehicle-fleet storeroom.

Concerning parts and the determination of when to reuse and when to junk them, fleet operators desire satisfactory operation but can hardly afford to bring older vehicles back to production tolerances. Therefore, the following is suggested for consideration: Each manufacturer to furnish service stations with information covering production tolerances; more liberal tolerances for guidance in repairing two-to-three-year chassis; safe tolerances for the four-to-six-year chassis; and extreme-limit tolerances for patch repairs to old chassis. With these data available, parts would be junked on a more scientific basis than that of the "hunch" method now in vogue, it being assumed that in all cases parts would be examined for indications of failure due to fatigue.

The full operation of service stations during the night is also of interest to fleet operators. This originates the suggestion, which may be possible of solution

TABLE 1—TYPICAL ORGANIZATION FOR A 500-VEHICLE FLEET WITH COMPANY-OPERATED REPAIR-SHOPS, UNDER PLAN 1

Superintendent of Transportation

1–Office Manager	1–Operating Supervisor	1–Shop Supervisor	1–Engineer
2–Stenographers			1–Draftsman
2–Clerks	5–Inspectors	5–Foremen	1–Clerk
	30–Mechanics	30–Mechanics	
	10–Washers	5–Stockmen	
	10–Garagemen		

Total Motor-Vehicle Personnel	106
Total Operating and Shop Employes	85
Total Vehicles per Employe	5—
Vehicles per Operating and Shop Employe	6—

TABLE 2—TYPICAL ORGANIZATION FOR A 500-VEHICLE FLEET USING MANUFACTURERS' AND COMMERCIAL REPAIR-SHOPS, UNDER PLAN 2

Superintendent of Transportation

1–Office Manager	1–Operating Supervisor	1–Supplies	1–Engineer
2–Stenographers	10–Inspector-Repairmen	1–Clerk	1–Draftsman
2–Clerks	10–Mechanics		1–Clerk
	10–Washers		
	10–Garagemen		

Total Motor-Vehicle Personnel	52
Total Operating Employes	40
Total Vehicles per Employe	10—
Vehicles per Operating Employe	13—

without seriously affecting the use of varying tolerances, that spare rebuilt units be carried in service-station stock so that defective units can be replaced quickly during the night without loss of operating time for the vehicle. In such case, day mechanics would make the necessary repairs to the removed units.

Selection of the Chassis

In the selection of the type of chassis to be purchased, the fleet superintendent studies every engineering development of the automotive industry. It is his duty to weigh the merits of one chassis against those of others and to compare their suitability for the job to be done. The American market affords 93 makes of motor-truck from which to select, the prices ranging from about $500 to $7,500. Shall it be a low-first-cost chassis or is a larger initial investment to secure more rugged design justified? If, for example, we admit gasoline, lubricant and tire consumption in the light-truck class to be comparable in both a low and a high-priced chassis of like manufacturer's capacity-rating, we have left for study as variables the first cost represented by depreciation, the repair cost, the time lost due to repairs, and the expected length of life. Assuming three years and six years, respectively, for the economical service life of the two chassis and calling on the past cost-experience available in each well-managed fleet, the one would be balanced against the other, and, based on identical operation within the ability of the lower-priced chassis, the use of two low-priced chassis of three years' life each compared with one high-priced chassis having a life of six years might show a slightly lower over-all cost together with other advantages. If it is intended to overload, however, or to travel unimproved roads, experience may indicate different results which prove the necessity for the ruggedness built into the high-priced chassis. The theory

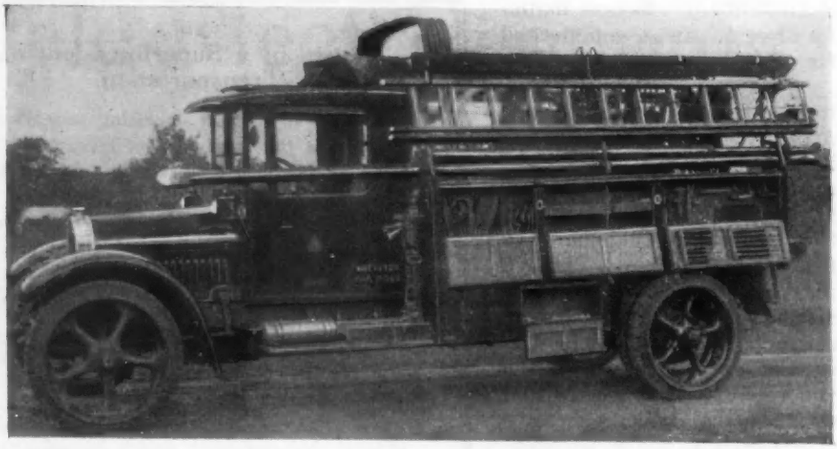

FIG. 2—TYPE OF CONSTRUCTION-TRUCK BODY USED FOR POLE-LINE AND CABLE CONSTRUCTION-WORK; IT HAS SIDE BOXES ABOVE THE PLATFORM AND MOUNTS ON A 2½-TON CHASSIS

advanced by some fleet operators that a larger-capacity chassis can be operated at say one-half load for less money than can a lighter chassis at a rated load does not seem to work out in practice. Therefore, the operator should think twice before stepping-up the capacity of his trucks, unless the job to be done dictates the necessity.

In considering the low-priced versus the high-priced chassis, the latter was considered as having been junked after six years of service and perhaps this life expectancy for a rugged chassis is not much short of the point where obsolescence, hastened by the rapid strides in automotive engineering, sets in. Therefore, when this point is reached it seems advisable to take the "velvet" in the final period of the running down of the chassis and trade them in for the realization of the increased economies built into the later product; but, after stopping extensive repairs on an old chassis, it should be kept in safe condition for the driver and for the public until the end of its last day in service.

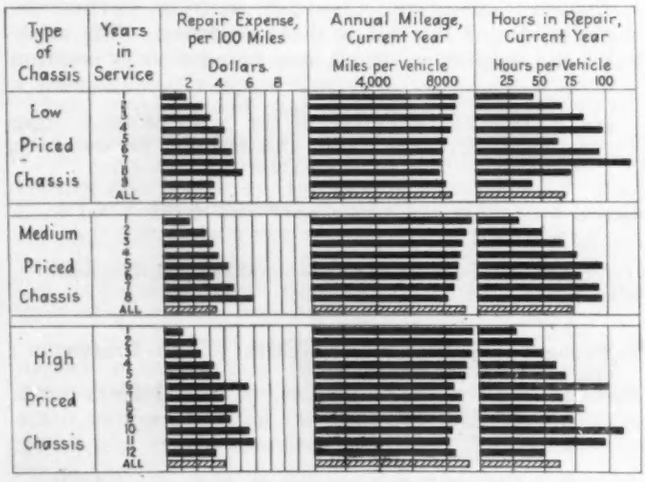
Type of Chassis
Years in Service
Repair Expense, per 100 Miles
Dollars
2 4 6 8
Annual Mileage, Current Year
Miles per Vehicle
4,000 8,000
Hours in Repair, Current Year
Hours per Vehicle
25 50 75 100
Low Priced Chassis
Medium Priced Chassis
High Priced Chassis
1 2 3 4 5 6 7 8 9 ALL
1 2 3 4 5 6 7 8 ALL
1 2 3 4 5 6 7 8 9 10 11 12 ALL

FIG. 1—CURRENT OPERATING-RESULTS FOR LIGHT-TRUCK CHASSIS GROUPED ACCORDING TO NUMBER OF YEARS OF SERVICE

Rebuilt-Chassis Operating Cost

Disregarding the obsolescence factor and electing to rebuild each chassis continually to last an unlimited number of years, what trend can we expect in operating costs? Not as an answer but for illustration of the problem, Fig. 1 shows repair-cost peaks at the fourth, fifth and sixth years of service, respectively, for the low, the medium and the high-priced chassis. Following these first peaks is a period of more favorable costs, after which even higher peaks are found, which can be taken to indicate that the tapering-off of extensive repairs should start with the third, fourth and fifth years, with respective replacement at three and one-half, five and possibly seven years.

Concerning the economical service-life, no set rules have been found effective; but it has been demonstrated that there is a critical point in the life of a chassis beyond which it is uneconomical to make extensive repairs. This point is indicated when the cost of immediate repairs, plus the estimated running maintenance during the period of extended life, is greater per unit such as the mile, hour and ton-mile, than is the cost of running maintenance for the first-life period of a new chassis. In this consideration must be included

the increased depreciation for the new chassis. The critical point for each class, type or make of chassis can be approximated from past records and, as such chassis approaches this point in service, consideration should be given to its replacement. Individual consideration of each chassis is stressed for the reason that, depending upon the driver's expertness, the territory covered and the work performed, some chassis will operate economically in excess of others and, therefore, the calendar and the odometer are not conclusive evidence in chassis replacement.

Specialized Body Designs

Considering truck-body design, the greatest interest now seems directed toward improvement in appearance. Utility in design has been developing continuously; but the appearance factor of these moving advertisements for their owners is receiving more and more attention, with perhaps the greatest improvement during 1928. Enlisting the aid of artists, fleet operators discovered that the lines of the prevailing truck bodies gave a high stubby appearance, that long sweeping effects were absent, and that the prevailing paints were too drab. Paint provided the quickest transformation for the vehicles in the field, and colors representing every shade of the rainbow made their appearance. Factory designers also cooperated by contributing de luxe panel bodies, lower chassis and various complementary-color schemes.

In a public-utility fleet, body design follows along somewhat specialized lines, as illustrated in Figs. 2 to 6.

Fig. 2 shows a construction-truck body for a 2½-ton chassis. It has side boxes above the platform and is used for pole-line and cable construction-work. The type shown in Fig. 3 is for a 1½-ton chassis and has side boxes above the platform only on the right. It is used for light-construction and for maintenance work. The type shown in Fig. 4 mounts on a 2½-ton chassis and is used for pole-line and open-wire construction-work but has no side boxes above the platform. The earth-boring-truck body shown in Fig. 5 is mounted on a 3-ton chassis and has side boxes above the platform only on the left side. This outfit is used for pole-hole digging, pole-line and general construction-work. Another body of similar design is used on a 2-ton earth-boring chassis. The six-wheel cable-delivery outfit of 15-ton capacity shown in Fig. 6 is used to deliver and spot cable on the job in large cities.

FIG. 4—TYPE OF CONSTRUCTION-TRUCK BODY USED FOR POLE-LINE AND FOR OPEN-WIRE CONSTRUCTION-WORK, DESIGNED FOR MOUNTING ON A 2½-TON CHASSIS

Adequate Garage Facilities

A pleasing design of truck body and an attractive painting scheme accomplish their mission only so long as the vehicle is kept clean and is repainted when necessary to approach its original condition as nearly as is practicable. This leads to a consideration of garaging facilities for the proper care of the vehicles. The arrangements of a garage have also a direct effect on the appearance of the fleet, as well as offering opportunity for favorable reaction from the garage personnel and the drivers. Some of the items to be considered are:

(1) If plot costs, location and other factors permit, a single-story building without roof-supporting columns is desirable, located on a corner plot with access from two parallel streets.

(2) Maximum-size window-openings should be provided and, in a single-story building, skylights can be utilized to supplement the lighting of the darker side.

(3) Efficient night-lighting should be assured by providing circuits to furnish general illumination, and also localized illumination of greater intensity.

(4) Doors may be horizontal, double sliding, jack-knife or of the vertical roll-curtain type, and should be equipped for automatic operation.

(5) An aisle, by rule of thumb, should be as wide as the length of the vehicles that face it.

(6) Floor drains should be centered in the aisles and spaced at about every 20 ft.

(7) The floor should be of smooth hard-finished concrete and have a slope of about ¼ in. per ft. from all directions toward the drains.

(8) Adequate heating and ventilating facilities should be provided.

(9) Convenience outlets for air, electricity and power-washing

FIG. 3—BODY FOR LIGHT CONSTRUCTION-WORK AND FOR MAINTENANCE
The Body Mounts on a 1½-Ton Chassis and Has Side Boxes above the Platform only on the Right

should be provided on the walls behind the vehicles about every 20 ft. This is based on servicing in place and washing in the aisles.

(10) Vehicles should be parked to provide a space at least 1 ft. wide between them. It also is advantageous to provide a passageway behind the vehicles and between rows of vehicles.

Expressing Cost Efficiency

Cost keeping is the subject of constant argument among fleet superintendents, each being likely to think that his own system is the most satisfactory. For this reason the arrangement of costs shown in Table 3 is given only as a basis for the development of a plan for expressing cost efficiency that has been found useful in making comparisons between the various geographical units of a large fleet.

It is recognized that rents for leased quarters, house-service for owned quarters, license fees and the like, enter into over-all fleet-costs; but, for the purposes of the measurement plan, these have been omitted as too greatly influenced by factors outside of the control of the fleet personnel. This plan compensates for the mileage traveled and the make-up of the fleet, and is based on the comparison of basic-cost figures with the actual costs.

In formulating the basic-cost figures for the plan, more properly termed the "index," the past operation of the total fleet should be analyzed separately by capacity or by working groups of vehicles to secure representative running costs for gasoline, lubricants, repairs and tires, to be applied against the actual mileage traveled; and representative non-running costs for general supervision, garage service and depreciation, to be applied against the number of vehicles in the particular group concerned. When these values have been determined, it seems advisable to go back and eliminate those vehicles showing unusually high cost. These second basic values, when applied in accordance with the following example, result in an index somewhat less than 100 for average-cost performance.

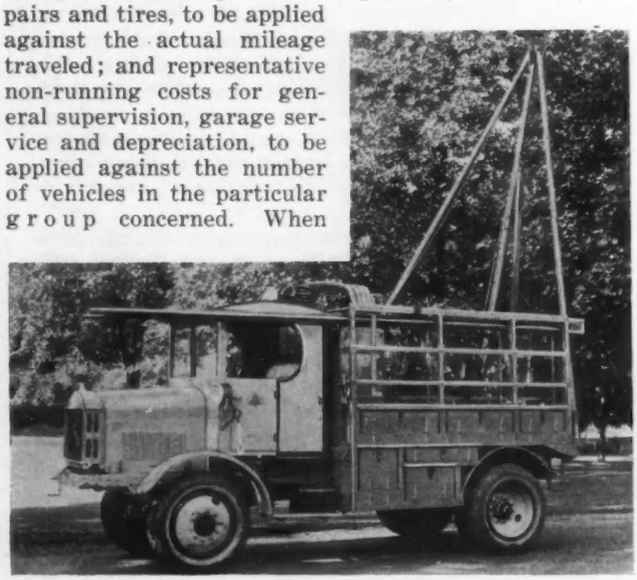

FIG. 5—TYPE OF BODY USED FOR GENERAL CONSTRUCTION-WORK, POLE-HOLE DIGGING AND POLE-HOLE CONSTRUCTION

The Body Shown Is Mounted on a 3-Ton Chassis and Has Side Boxes above the Platform only on the Left Side. Another Body of Similar Design Mounts on a 2-Ton Chassis. Both Body Designs Are Suited to the Installation of Earth-Boring Equipment for Digging Pole-Holes

FIG. 6—SIX-WHEEL CABLE-DELIVERY UNIT OF 15-TON CAPACITY USED TO DELIVER AND SPOT CABLE ON THE JOB IN LARGE CITIES

Determination of a Cost Index

For a light-truck group let

A = Running index value; for example, \$0.05 per mile

B = Non-running index value; for example, \$25 per vehicle per month

C = Actual mileage traveled; for example, a total of 22,312 miles

D = Average number of light trucks in service; for example, 27 units

E = Actual running and non-running costs; for example, a total of \$1,861

Then

$$\frac{(A \times C) + (B \times D)}{E} = \text{Index} \qquad (1)$$

For the example cited we have

$$\frac{(0.05 \times 22{,}312) + (25 \times 27)}{1861} = 0.96 \qquad (2)$$

The result in equation (2) is termed a "96 index." For the initial application of such an index it seems desirable to set the basic values sufficiently low to provide abundant opportunity for improvement before an index of 100 can be reached, because the figure 100 has so long represented perfection to the human mind that there may be a slacking off in effort when this goal has been reached.

The "composite index" for all groups of vehicles in a fleet can also be secured by adding all quantities

TABLE 3—COST ACCOUNTS USED IN THE MEASUREMENT PLAN

Account
Running Costs on a Mileage Basis
Gasoline
Lubricants; engine and chassis
Repairs, except tires and due to accident
Tire repairs
Tire replacements
Non-Running Costs on a Vehicle Basis
General supervision
Garage service; washing, gassing, oiling and greasing
Depreciation of motor-vehicles by make or type and capacity
Depreciation of garage equipment

$(A \times C) + (B \times D)$ together and dividing by E, representing the total actual running and non-running costs for all groups. It is possible, however, to secure a favorable cost-index and yet do a very uncreditable maintenance job, which leads me to suggest the separate measurement of the quality of maintenance and the appearance of the vehicles under each inspector or inspector-repairman. Some of the factors concerned are the frequency of road break-downs, the number of hours idle for repairs, the relative life of the chassis, the productivity, cleanliness and painted appearance of the vehicles, and the like. In turn, it is possible for the inspector-repairman to measure the quality of the individual drivers along lines of frequency of accidents, relative life of the various mechanical units of the vehicle, the mileage secured from tires and gasoline, and so on. The measurement of quality does not readily reduce to a formula, although arbitrary values for the various factors can be set. A quality index must be administered on an impartial basis, because the success or failure of the plan depends upon fairness to the personnel so measured.

In conclusion, and notwithstanding the marked developments of the last few years, I believe it a timely plea to request even greater cooperation between the automotive manufacturers, the fleet operators and the Society in the further improvement of the efficiency and utility of the motor-vehicle.

THE DISCUSSION

PIERRE SCHON[2]:—How does your company establish its basis of depreciation on the vehicles?

F. K. GLYNN:—Depreciation is established in keeping with expectancies based upon past experience as to months of life and salvage value for each general type of motor-vehicle.

MR. SCHON:—Up to say five years ago, the average mileage per vehicle for figuring depreciation was well established, but long-distance hauling has developed and it is not unusual for a motor-truck to travel 60,000 to 75,000 miles per year where formerly a basis of 20,000 miles was regarded as a fairly good average. In such a case, is it not proper to establish depreciation on a mileage basis first?

MR. GLYNN:—In a public-utility fleet the high mileages mentioned seldom occur, because the vehicles are used principally as mobile labor and time-saving aids to the workmen.

MR. SCHON:—Are your repair costs in detailed form as to engines, transmissions, axles and the like?

MR. GLYNN:—The accounting procedure followed provides for the segregation of the repair costs for each unit of the vehicle, if desired; but, ordinarily, unit cost-keeping is instituted only for periodic check and is not practised as a general rule.

G. W. THOMAS[3]:—We are trying to minimize wear, which is the cause of depreciation, by using governors as standard equipment on truck engines. We also attempt to make maintenance easier by using interchangeable units. For example, we are trying to standardize parts so that some particular part such as a shaft will fit different models.

Determination of Tire Type

K. D. SMITH[4]:—How can small-fleet operators determine when to use solid, cushion or pneumatic tires? How can they determine which type of tire is most economical for a given service?

MR. GLYNN:—It is my opinion that daily operating conditions, such as roads, mileage, allowable speed and tractive ability required, should govern the selection between solid, cushion and pneumatic tires for trucks of 2-ton capacity and over. For less than 2-ton capacity, pneumatic tires now seem to predominate. For the larger trucks operated on the well-paved streets of metropolitan centers, traffic congestion may limit the speed and mileage to such an extent that solid tires are most economical. In suburban areas, cushion tires may find a useful field; in the country, it is probable that the pneumatic tire should be given preference.

MR. THOMAS:—Various State legislatures are discussing whether or not solid tires should be ruled off the roads. If some State legislates against the use of solid tires because of their bad effect on the roads, operators will be barred from using such tires. Tire and car manufacturers and motor-vehicle operators, even when working in cooperation with the Bureau of Public Roads and the Bureau of Standards, have difficulty in getting equipment that will be economical. I fear that in the endeavor to conserve the good roads, the tendency is to go too far into the economics of the question with regard to the motor-vehicle. Some of the States which do not possess technical data on the effect of solid-tire impact on the roads neglect the factor of speed. Both the load and the speed of travel affect impact, and it is forgotten that the speed laws reduce the amount of impact.

Maximum Permissible Loading

QUESTION:—Does Mr. Glynn keep within the rated load specified or does he overload tires?

MR. GLYNN:—We try, with, I believe, better than average success, to provide adequate tires for our vehicles and to keep within the manufacturers' gross-weight limit.

G. A. GREEN[5]:—I favor the standardization of balloon tires on the front and the rear wheels of all motor-trucks. I realize, however, that in some cases solid tires must be employed; for example, under certain conditions discussed by Mr. Glynn.

CHAIRMAN B. J. LEMON[6]:—How will the gross-allowable-load law stop overloading? Who shall say what the gross allowable load is?

A MEMBER:—The manufacturer.

CHAIRMAN LEMON:—The manufacturer says now that a 2-ton truck will carry 2 tons, but the fact is that the truck is carrying say 4 tons. Suppose the manufacturer includes in the gross weight the body and the

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[2] A.S.A.E.—Sales engineer, General Motors Truck Co., Pontiac, Mich.

[3] M.S.A.E.—Service engineer, Reo Motor Car Co., Lansing, Mich.

[4] Manager, tire construction and design, B. F. Goodrich Rubber Co., Detroit.

[5] M.S.A.E.—Vice-president in charge of engineering, General Motors Truck Corp., Pontiac, Mich.

[6] M.S.A.E.—Field engineer, tire-development department, U. S. Rubber Co., Detroit.

pay-load; who will hold the weight to that specified figure in actual service?

A MEMBER:—One important point is that, having established a maximum permissible gross load, the manufacturer is in a position to refuse to give any free service in case of loading that exceeds the specification. If the buyers are convinced that there is a definite maximum permissible gross load, that will go far toward eliminating the trouble.

A MEMBER:—Establishment by the manufacturer of a maximum permissible gross load will eliminate any injustice in cases where a State may raise the license rate on account of overloading and its tendency toward greater road destruction. If this load rating is displayed on the vehicle so that it is visible to the inspectors on the State roads, they can determine whether the vehicle is overloaded and report accordingly. In such case the manufacturer's guarantee ends when the specified permissible gross weight is exceeded.

JOHN P. COE[7]:—Regarding records of tire performance, does your company keep a ledger account of each tire, or is an accurate record of tire performance kept?

MR. GLYNN:—We do not maintain a ledger account for each tire purchased, but we do maintain a life-record of a sufficient percentage of the tires used to provide operating and engineering data.

Kinds of Tire and Permissible Loads

MR. THOMAS:—Comparing balloon tires with high-pressure tires, I feel that the former will be increasingly installed on trucks as the speed of the trucks increases. My experience in high-speed truck-operation in some of the hot districts of the West leads me to believe that a balloon tire can be built which will carry the load at high speed more economically than will the high-pressure type.

L. P. KALB[8]:—More need for cooperation between the designers and the operators exists at present than ever before. The demands on the motor-vehicle have multiplied more than most people realize, and the designer should be in closer touch with the operator so as to meet the operating requirements. Operators who have kept adequate cost and maintenance records over a period of years have found it necessary to avoid abusing their vehicles; particularly by overloading them.

C. J. BOCK[9]:—Regarding the maximum permissible gross load, trucks were formerly designed on a somewhat arbitrary basis and a 1-ton truck was expected to haul 1 ton; but, in practice, the operators overloaded them excessively. Specifying the maximum permissible gross weight affords a basis for service, sales and engineering, as well as encourages the work of the tire manufacturers.

Maintenance by the Manufacturer

MR. GREEN:—I am impressed by Mr. Glynn's suggestion that the manufacturer relieve the operator from the burden of stocking spare parts and the carrying out of repair work generally. Where operators seriously contemplate such a plan, it seems reasonable to expect that a mutually satisfactory basis could be worked out when the equipment is purchased and, at that time, if the manufacturer were in a position to obtain something tangible in the way of a guarantee for repeat business, a very favorable maintenance contract might be executed.

From a personal viewpoint the contract repair-system has no particular appeal, especially where a large fleet is involved. It seems to me that an operator should be able to organize his repair shop on a sound and economical basis and, assuming that this is the case, then he can save the service-station profit.

I am very much in sympathy with the perfection of service-station methods, such as tooling and the like. The General Motors Truck Co. has, at Pontiac, Mich., an elaborate service-installation, including a school in which regular classes are held daily. A considerable amount of time and money has been expended in connection with the design of special tools, the use of which is explained during the classes.

HENRY DAKIN[10]:—The suggestion has been made by the previous speaker that the operators should decide whether they want the manufacturers to sell them transportation on a per-unit or a per-mile basis; that is, maintain the vehicles for a certain specified sum. The flat-rate system is not a fair basis for an individual; taken as a group, perhaps the operation may average a certain price, but when a car needs a valve-grinding job perhaps the cost equals the average rate and perhaps it is only one-third or one-quarter that rate. We operate about 800 motor-vehicles in Michigan under varying conditions, depending upon the location to which the vehicles are assigned. A similar condition probably obtains between two small-scale operators; hence we are not and they are not in a position to set a price for which all the vehicles will be maintained, and I think also that manufacturers are not in such a position. If the manufacturer does set such a price, someone must pay the long price for a short amount of work. A better plan would be to set up what perhaps would be a maximum charge for a specific maintenance-operation, with an actual charge based on the time spent in making repairs and on the cost of the parts needed.

An important point suggested by Mr. Glynn is that of excessive repair-costs due to the unnecessary replacement of parts. For example, after investigation of a recent case wherein a car was sent to a service station for repairs, the manufacturer's representative found that the charge for labor was excessive because the inefficiency of the organization had allowed parts to be replaced unnecessarily. We, as operators, look to the manufacturer to set up a series of tolerances for each part so that we can know when parts are in need of replacement. Second, the manufacturers should determine the time in which maintenance jobs should be completed so that they can specify to their agencies and branches and to the operators the amount of time needed on each type of repair job. Then, if more time than that specified is taken, it suggests that the work needs reorganization and mechanics need instruction.

Selling Service in the Field

MR. GLYNN:—The manufacturer goes out into the field and sells his vehicles; therefore, why should not the manufacturer sell his service? Without doubt, fleet operators expect the manufacturer to make a profit on service, because only under such conditions will good

(*Concluded on p.* 158)

[7] Development engineer, tire department, U. S. Rubber Co., Detroit.

[8] M.S.A.E.—Assistant chief engineer, Continental Motors Corp., Detroit.

[9] M.S.A.E.—Chief engineer, General Motors Truck Co., Pontiac, Mich.

[10] A.S.A.E.—Superintendent of buildings, motor equipment and supplies, Michigan Bell Telephone Co., Detroit.

Outboard Motorboat Hulls of Today

By Jacob Dunnell[1]

New England Section Meeting Paper

Growing popularity of outboard motorboats has led boat-builders to seek improved forms of hull that give high speed with relatively small engine power while preserving stability. A multitude of different shapes of hull are in use but, according to the author, they may all be classed under the following heads: round-bottom, concave-bottom and V-bottom. Each of these classes has many subdivisions and each has its characteristic behavior.

Among the many interesting ideas with which designers are experimenting is the use of separate planes under the boat to raise almost the whole hull out of the water.

The expenditure of outboard-engine power in boat propulsion is analyzed. The propeller shows a 35-per cent loss of efficiency, while 5 per cent of the engine power is used in overcoming air resistance, 25 per cent is expended on wave-making resistance, 30 per cent is lost by skin friction and 5 per cent through eddy-making resistance. Technical improvements are to be expected chiefly in the direction of reducing wave-making resistance. The importance of reducing the wetted surface of the boat to a minimum is mentioned.

THE recent remarkably rapid development of the outboard engine has necessitated a complete revision of the hull design; in fact, revision of former types was not sufficient, and new types had to be created. It must be understood that, while little enough is known technically about the older types of planing boats, still less is known regarding the newer ones being developed for the outboard engine. The hulls are so inexpensive that any elaborate study or experimental work concerning them is not worthwhile, and the changes come so fast that the results of almost any research would be out of date by the time it was completed.

Hence, in the outboard-boat industry as it exists today, trial and error provide virtually the only design method used. If a designer carefully follows the various types that have been successful, he can draw a set of plans that he is certain will perform satisfactorily; yet, if he is honest, he will admit that he does not know exactly why each detail works out as it does. If a designer were asked to draw up an entirely new set of plans embodying an idea not found in present boats, he probably would be glad to do so but would not guarantee performance. There are no formulas to follow, no textbooks to refer to, and very few precedents that would be of any help to him.

This is a great handicap to the industry, on the one hand, as much experimental work must be done before a model can be put on the market. On the other hand, it has led to the production of a vast number of totally different hull-types, which we shall be able to divide eventually into the good and the bad, and to find the reasons for their reactions.

The Three General Classes of Hull

Most present hulls may be classed either as round, concave or V-bottom designs. Each class has many subdivisions such as monoplane, biplane or single step, multiplane and the like, but the performance in each main class is typical.

The V-bottom type, either with or without steps, probably has enjoyed the greatest popularity. It is used almost universally in the larger planing boats, and many designers still employ it in the outboard field. However, in the extremely light and fast outboard boat of today, we note a marked trend away from the V-bottom. The light weight of such boats results in a very small part of them being in the water; while the V-bottom boat, to function properly, must have a considerable surface in the water, as otherwise it will skid on the turns, in which event it is very likely to catch its sharp outer chine and trip. To offset this, most of the racing types are designed with fins attached to the keel fairly well forward. This arrangement tends to counteract the skidding but at the same time the action of the fin when the boat skids makes the boat bank to the outside of the curve, which is very dangerous. However, at present the V-bottom is often modified by using a rounded chine-section. While this rather increases the skid, it renders it much less dangerous, as there are no sharp edges to catch and turn the boat over. This type of bottom is probably as efficient as any in the ordinary straight-away or for heavier boats, but in another year or two it probably will be used no longer in very light boats, especially those of the outboard type.

The old round or convex bottom, which has been used for centuries in boats of different shapes and sizes, is coming into its own in the racing field. Until last year, it was used universally in slow boats but was not thought of for racing bottoms. However, making it sharper at the bow and flattening it out into nearly a flat bottom at the stern, has made it very fast, especially in rough water, and it performs better on the turns than any other type of fast boat. The convex shape of the bottom makes a sharp entrance into the water almost impossible, which is probably the reason that it is not very fast on the straight-away or in calm water. This type, however, has many good

[1] Naval architect and chief engineer, Eastern Service Marine Co., Boston.

points, such as facility in turning, ease of construction, and stability; and, as less experimental work has been done on it so far than on most other types, we undoubtedly shall hear more about it in the future.

The third general type is the concave bottom. This has two distinct advantages: First, it throws most of its spray underneath it, ensuring plenty of air under the boat and very clean running, with almost no spray on the sides. Secondly, the outer chines are the lowest part of the boat, so that, no matter how much the hull comes out of the water, this outside chine is always in the water and gives great stability on the straight-aways. For this reason, it can be driven on a very small wetted surface, with the minimum resistance. One of the most efficient boats of this type I have seen was all but about 8 in. out of water, with less than 2 sq. ft. of wetted surface, due to the stability of the outside chines, which is not obtained with the round or the V-bottom. Because of the hollow bottom, however, this type has the disadvantage that the chines are the lowest part of the boat. This is an advantage in the straight-away, but in turning it offers a very sharp edge which catches very pronouncedly.

Freak Ideas May Become Practice

Besides these three general types, there are a number of hull forms called freaks today but any one of which may become accepted practice tomorrow. With the changes coming in this field as fast as they do at present, no new idea should be turned down until it has been proved unsatisfactory.

One new idea sure to be heard from involves the use of separate planes placed under the boat to raise the entire hull bodily out of the water. This idea was tried successfully by Dr. Alexander Graham Bell a number of years ago and is now being developed for outboard boats. Theoretically, this plan is nearly perfect; it minimizes the wetted surface and almost perfect stability can be obtained by placing the planes as far apart as possible. With very thin planes, the suction on the top as well as the pressure on the bottom can be used as lift and the area of the planes reduced. The use of separate planes also permits streamlining of the whole boat to reduce air resistance. This last factor is becoming important at the speeds which outboards are now developing and deserves consideration.

However, this type has many practical or mechanical disadvantages. To be efficient, the planes must be very thin and are therefore difficult to make strong, so they are easily damaged by driftwood. With the whole boat rising out of the water at full speed, the propeller must be much deeper than is normal when the boat is at rest or moving at low speed, lest it come out of the water at high speed. The high center of gravity when the boat rises is very undesirable at the turns.

Stepless and Single-Step Planes

As I have stated, each of the three generic types of bottom has many subtypes. If the bottom is continuous from one end to the other, it is classed as a monoplane or stepless type. This is used in all slower boats and in most medium-speed hulls such as runabouts, but is seldom used in fast racing boats, except in very short hulls where two planes would be at too great an angle. The next and most popular type in the race boats is the biplane or single-step bottom, on which more data are available than on any other type. When used with an inboard engine, as is done in all bigger classes, the hull is calculated to balance on the after-end of the forward plane. This means that the whole after-plane, which carries almost no weight, acts merely as a balance and as a support for the rudder and propeller. In the outboard boat, the situation is totally different. Engine, propeller and everything comprising the power and propulsion unit are hung on the transom over the stern. For convenience, it is desirable also to have the driver located near the stern where he can operate the engine best. This means that in the single-step plane both planes must be completely redesigned, so that the boat will balance on its after-plane, the forward plane acting merely as the balance, with nothing behind the engine to support the stern.

For this reason many outboard boats, when getting under way, seem to have the bow sticking up at an angle of about 45 deg., and it is very difficult to make some of them plane at all; but, after reaching planing speed, they double their speed in the fraction of a second. The high angle is an advantage in that the wetted surface is kept small, but longitudinal stability is never very good, and difficulty is often experienced in getting the bow down to start the boat planing. Besides, to carry the weight of the engine, the stern of the boat must be wide, and this causes great wind resistance. If the engine could be placed over the step, as in the larger hulls, I believe a far more satisfactory boat would result.

How the Engine Power Is Used

It may be of interest to know how the power is expended in driving a fast boat. Most persons suppose it is all used in driving the boat through the water, but pushing through the water offers only about 25 per cent of the total resistance. Let us assume a fast single-step outboard boat with an engine delivering 20 hp. to the propeller. At the propeller we have one of the greatest losses in the whole unit. No high-speed and very few low-speed propellers have an efficiency of more than 65 per cent. In the 20-hp. outfit 7 hp. is therefore spent in churning the water and in skin friction on the propeller blades, leaving actually 13 hp. to drive the boat. If the hull is not streamlined more than usual, about 1 hp. is wasted in overcoming air resistance, mostly under the step, behind the stern and in eddies in the cockpit. In going through the water the boat throws out waves which do not seem to be very large with fast boats but which, if carefully measured, are found to be of considerable length and small amplitude and to have a high velocity. In this wave-making resistance of a small, light, fast boat about 25 per cent of the total power—5 hp. in the case we are supposing—is lost. Skin friction of the hull at high speeds consumes the greatest amount of power, approximately 30 per cent, or 6 hp., even if a very fast finish on the bottom is available. The remaining power is divided among a few minor losses, most of it being used up by the eddy-making resistance caused by the fins and so forth.

These losses are easy to reduce to some extent. For instance, the skin friction is always lessened by the very best possible finish on the bottom, usually graphite. Air streamlining will be better this year than in the past, as it is not a very complicated problem, so the air-resistance may be cut in half. Streamlining of the underwater part has been carried nearly to the limit,

so the eddying resistance cannot be decreased very much. Propeller efficiency has been experimented with for years, and seemingly no advance is being made in this respect.

Data Needed on Action of Planes

Wave-making resistance thus remains the only unknown element to be reduced. This factor depends entirely upon the shape of the planing surface and its angle of attack. If the surface of the plane is divided into two or three small planes on a very light fast boat, its area and angle can be calculated very accurately from the hydraulic formula used for planes in a moving body of water. This is the only available check. With planes a little larger or with a curved surface, as in most cases, no means of calculating the most efficient surface are available; it can be determined only by process of trial. This necessity of testing planes of various shapes and sizes holds back the development not only of outboard boats but of all planing boats. Their testing is expensive and the results are not very satisfactory when original boats are as small and fast as those used in racing. To test them accurately in actual service is almost impossible, as instruments cannot be carried on board the outboard boat without reducing the speed by 5 m.p.h., even if they could be read while the boats were going.

Some method must be evolved of finding out how the planing surface acts and how its efficiency can be increased. In the case of an airplane, virtually all the facts are known; in boats, where nearly all the work has to be carried on under the bottom, so to speak, nothing is known. We hope that some engineering firm possessing sufficient capital and interested in boating will start work in the near future to find the data we need to put boats on a sound engineering basis. I believe that possession of really accurate information regarding the planes on boat bottoms will enable us to double the seaworthiness and increase by 50 per cent the speed of outboard craft.

THE DISCUSSION

QUESTION:—Has any attempt ever been made to mount an outboard engine on each side of the boat more nearly amidships to eliminate the trouble at the stern?

JACOB DUNNELL:—I do not know of any such attempt. In some cases, however, the engine has been mounted amidships in a well, which gave somewhat the same effect except that the slipstream under the boat was found to increase the resistance. Besides, if the engine is mounted anywhere near the middle of the boat, steering with the propeller is impossible and it is necessary to put a rudder on the stern, which considerably increases the resistance. Whether this would more than offset the advantages to be obtained from better design would have to be determined by trial.

QUESTION:—What ratio is used between the engine and the propeller?

MR. DUNNELL:—The gear ratio varies with different makes; usually it is about 20 or 22 to 12 or 14.

JOHN EVANS:—Does the wave under the surface of the water make any difference with the friction on top of the water? When two pieces of metal rub against each other, added weight put on them increases friction proportionately. Does the same principle apply to boats on top of the water?

MR. DUNNELL:—In a planing boat the object is to secure the least possible wetted surface. Some definite relationship exists between weight and speed, on one hand, and the wetted surface and speed, on the other hand. We do not know the relationship exactly but do know that it depends on the shape of the plane. If more weight is added, instead of increasing the friction, you simply increase the area of the wetted surface, thereby increasing the total resistance. With a boat that is free to rise out of or go down into the water, I do not think the friction per square inch of plane surface will be increased. The boat simply will not rise so far out of water if more weight is added and the wetted surface will be greater.

MR. EVANS:—My thought was that if a boat were made wide the surface friction would be increased but the friction between the surface of the boat and the water would be decreased because of the lighter weight, if the same principle applied as in any other substance.

MR. DUNNELL:—I do not think that would be the case, because even a very light boat with a largely increased wetted surface would be slower than a heavy boat with less wetted surface. The more surface that is kept in the water, the more the boat will slow down.

F. W. DAVIS[2]:—Have you had an experience in driving a boat through salt water in which there is floating seaweed? Floating eel-grass wraps around the fin and the boat almost stops, due to bad cavitation. Two or three strands are enough to cause that. The engine manufacturer advised me to use a weedless propeller. Would an incline or angle-plate just ahead of the fin deflect these weeds, causing them to pass under the lower end of the engine housing?

MR. DUNNELL:—A weed guard under there will usually keep the weeds from the propeller, provided the boat is not running at too great a speed. But I would not recommend this practice for a high-speed boat.

No Tanks for Speed-Boat Testing

V. A. NIELSON[3]:—Can you tell us something about the means used for experimenting on the bottom of a boat, finding out about the balance?

MR. DUNNELL:—For a large boat a model tank is used. For present-day high-speed boats that plan is not satisfactory with any model tank available in this Country, though I believe very accurate work is being done in some tanks in Europe. No tanks in this Country allow for a high enough speed of the towing truck with efficient recording instruments to give us any definite data about the bottoms. Therefore we have been building hulls with bottoms that have removable sections, or several hulls which are very nearly alike but have minor differences, and we measure the lift, speed and general action of these. This is a very crude, unsatisfactory method but is the only means I know of without a towing tank for high-speed boats.

[2] M.S.A.E.—Consulting engineer, Waltham, Mass.

[3] M.S.A.E.—Factory representative, Willis-Jones Machinery Co., Newtonville, Mass.

MR. NIELSON:—By a towing tank, do you refer to one provided with a machine for drawing the boats through the water?

MR. DUNNELL:—I mean one similar to the one in Washington but having a high-speed towing truck equipped with recording instruments.

MR. NIELSON:—Would it not be possible to erect an oval tank through which the water could be circulated rapidly? It would have to have a rather long straightaway, so that the action of the water would be smooth.

MR. DUNNELL:—It might be possible, but unless the tank was of large cross-section the eddying would be very serious.

MR. NIELSON:—What would be your opinion about using a combination in which both the water and the boat are moving in opposite directions?

MR. DUNNELL:—I think something like that might be possible. Of course, it is imperative that the water-flow be absolutely smooth and without eddies, otherwise the results will be very inaccurate.

Vehicle-Fleet Economics

(*Concluded from p.* 154)

service be rendered. Under any conditions, I believe that the amount of free service demanded for the vehicles of a fleet will be much less than that demanded for the passenger-cars bought by the public. If the manufacturers attempt to sell service, as they so successfully sell trucks, it will react in improved service-stations equipped with all kinds of labor-saving equipment capable of producing a better job than can be done with the limited equipment economically practicable for a small fleet.

MR. SCHON:—After a survey of the cost of various operations in maintaining and repairing our company's trucks, it was found that the same operation might cost $5 in one locality and $15 in some other. A prize contest was inaugurated for the best special tools devised by our various branches in 42 States. The ultimate result is that all our company's branches have a full set of labor-saving devices and tools, and it is not unusual for an operation formerly costing $25 to cost only $5 on account of these specialized tools. When a new model is brought out the manufacturer of our special service-station tools cooperates with our service department and special tools for this model are developed. All branch service-stations are supplied with a full set of labor-saving tools, which results in less labor and a lower repair-cost on jobs done in them. The truck owners derive greater benefit from their trucks because of the lessened time in which the vehicles are out of service for repair. All our service managers spend a week annually at our service school in Pontiac, learning how to use these special tools and labor-saving devices so that they can act as instructors to the mechanics in their home shops.

Regarding the flat-rate system, its adaptation to the maintenance of trucks by our various branches is progressing very rapidly, so that a flat-rate cost for any repair operation can be quoted regardless of truck size or model.

Flat-Rate-System Charges

W. R. STRICKLAND[11]:—I was surprised at Mr. Dakin's allusion to an instance of overcharging in connection with the flat-rate system. From what I know of the flat-rate system introduced by our company, a customer is more likely to get the work done at a low price than he was under the old system. I see no reason why the trend should not be the same in connection with motor-truck and motorcoach operation, although I realize that the operations may be so scattered that it may be difficult to bring the vehicles to a service station. The establishment of a service station that will care for the territory covered by the operations of the vehicles is a difficult problem; but, wherever large fleets are concentrated within a certain area, I believe that the service will be given by the manufacturers, under a flat-rate system, that the service station will be equipped with special tools and devices, and that the results will be better than they ever were before.

G. M. SPROWLS[12]:—We have seen several cases recently in which an operator has been put to considerable expense in changing wheel-housings and sizes of wheels to accommodate larger tires than those with which his motorcoaches originally were equipped. The reason for the larger tire is due to a number of causes, such as additional weight in bodies, heavier reclining chairs, extra gasoline tanks and, in some cases, toilets. Possibly, with standard bodies and equipment, the original tire-size would have been satisfactory; but, with additional weight added, the next larger size of tire is required to reduce road delays and give a reasonable average mileage. It would be highly desirable, from both the operator's and the tire manufacturer's viewpoints, that wheel and rim equipment, together with the wheel-housing, be provided that would permit oversizing.

[11] M.S.A.E.—Assistant chief engineer, Cadillac Motor Car Co., Detroit.

[12] M.S.A.E.—Manager, highway-transportation department, Goodyear Tire & Rubber Co., Akron, Ohio.

The Possibility of Increasing Fuel-Economy

By H. M. JACKLIN[1]

ANNUAL MEETING PAPER

Illustrated with PHOTOGRAPH, DIAGRAMS AND CHARTS

RESULTS of an investigation of operating a four-cycle 3 x 4-in. single-cylinder engine, using constant compression at all throttle settings, were published previously by the author, who now presents the data obtained from a continuation of the experimental work. Typical indicator-diagrams and curves are shown and commented upon, and comparisons of performance are made.

The relative performance of a car fitted with an engine operating under the various conditions is discussed and, in conclusion, the statement is made that active experimentation along the line of increasing fuel-economy is warranted because the possible aggregate savings to owners would be very great and consideration of the possible conservation of our visible petroleum stock would be of vast importance.

DESIGNERS of internal-combustion engines have always had a quest, and it has been a quest for power. The two latest developments of this quest have resulted in the use of larger cylinder-reamers and in increased compression. The first gives greater power because more air and fuel are handled by the engine; the second, because better combustion-characteristics result from its use. In this Country, the manufacturers have always been able to attract customers by using the slogan "more power" as the bait. But the average owner talks as much about his mileage as he does about get-away, and it seems that thought should be devoted to more productive solutions of this phase of automobile-engine operation. In other words, emphasis has been placed on acceleration and top speed, both requiring a high power-development at any given engine speed.

The object of this paper is to present some material that may help in solving another phase of car performance, that of increasing the over-all thermal efficiency at part load, the preponderant condition under which cars are operated. Since it is variously estimated that our cars are operated at part load from 70 to 90 per cent of the time, it seems that a rather large field is open for study.

Results of an investigation of operating a four-cycle 3 x 4-in. single-cylinder engine, using constant compression at all throttle settings, were presented in my paper on Improving Engine Performance[2]. Since that time J. F. Campbell, H. S. Dale and John Heiss have made a more detailed investigation which shows additional interesting data. The data presented were collected after various difficulties had been surmounted, and these data probably represent about one-third of the actual experimental work.

Indicator Diagrams Obtained

Fig. 1 shows a general view of the engine set-up, including the dynamometer and the high-speed indicator. Fig. 2 shows a series of typical diagrams obtained from the tests. The upper diagram was obtained when using full throttle. Those at the right show how the compression and the combustion characteristics changed with decreased throttle-openings when operating conventionally; that is, with a fixed clearance-space. The diagrams at the left were obtained with exactly the same throttle settings as those at the right but with the clearance volume changed to restore the compression to that used at full throttle. No great excess of inert gas was ever present in the mixture under these conditions. Likewise, there was never an excess of air in the cylinder.

The diagrams show clearly that better combustion re-

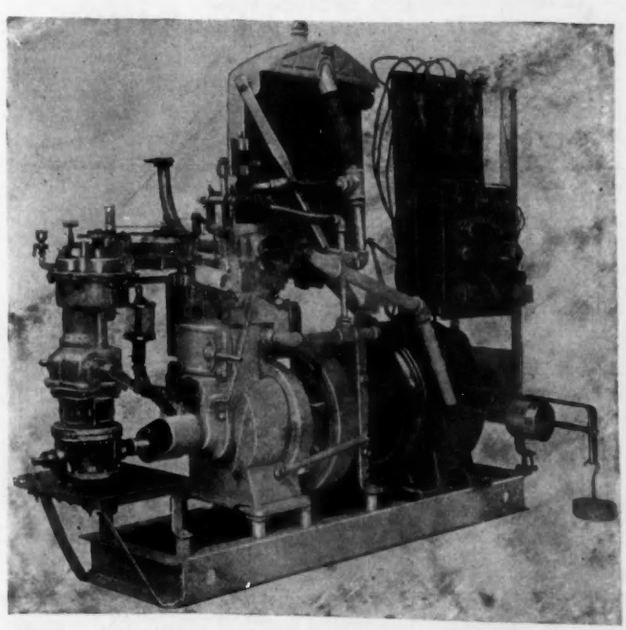

FIG. 1—VARIABLE-COMPRESSION ENGINE USED FOR HIGH-COMPRESSION CONSTANT-CLEARANCE AND CONSTANT-COMPRESSION TESTS

This Is a 3 x 4-In. Overhead-Valve Type Fitted with a Movable Head So That the Clearance Volume Can Be Changed Easily by Means of the Micrometer Screw at the Top. It Is Water-Cooled, with Thermosiphonic Circulation. The Engine Is Loaded by Means of the Cradled Generator at the Right

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[2] See S.A.E. JOURNAL, March, 1928, p. 337.

sulted at all part-throttle settings, the combustion and the expansion lines being smoother and higher with constant-compression operation than when constant-clearance operation was used. Those at ¼ and 3/16-throttle constant-clearance operation show some actual misses in the two diagrams in these tests, as evidenced by the drops from the expansion line to the compression line. Since the clearance volume was reduced for part-throttle loads when operating on constant compression, the amount of inert gas left in the cylinder at the end of the exhaust stroke became less and less as the quantity of combustible charge was reduced. This, together with the increased compression over ordinary conditions of operation, results in the very definite improved combustion characteristics which should result in the attainment of better thermal efficiencies at part loads or part-throttle settings. This is borne out in the performance curves.

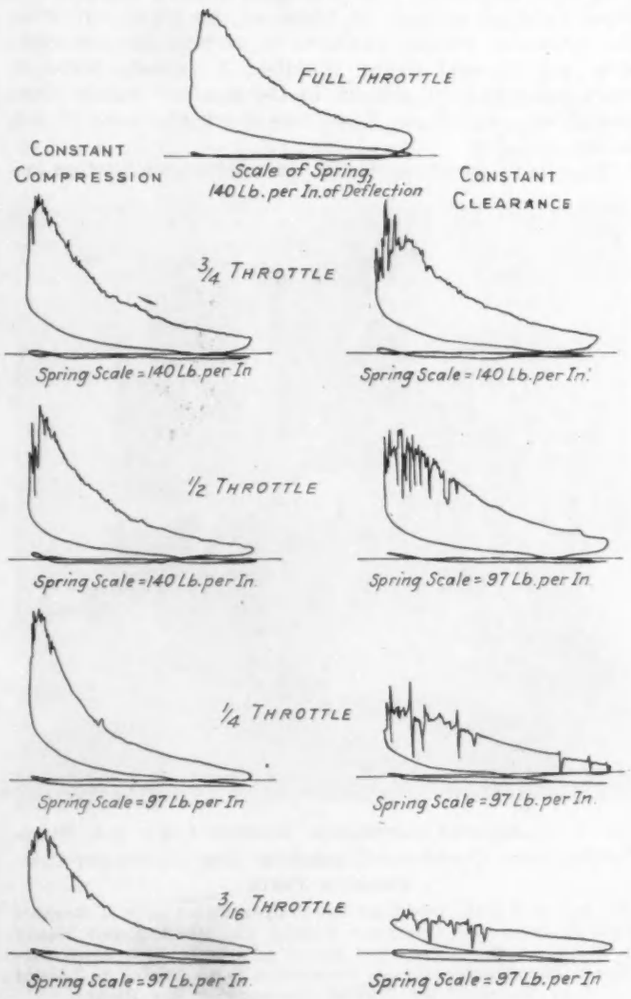
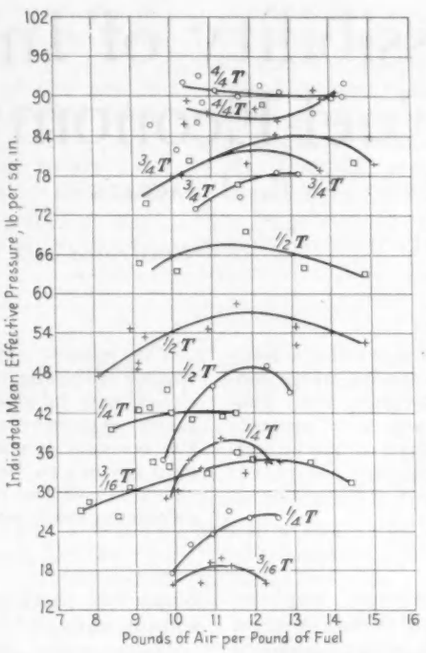

Full Throttle
Constant Compression
Scale of Spring, 140 Lb. per In. of Deflection
Constant Clearance
3/4 Throttle
Spring Scale = 140 Lb. per In.
Spring Scale = 140 Lb. per In.
1/2 Throttle
Spring Scale = 140 Lb. per In.
Spring Scale = 97 Lb. per In.
1/4 Throttle
Spring Scale = 97 Lb. per In.
Spring Scale = 97 Lb. per In.
3/16 Throttle
Spring Scale = 97 Lb. per In.
Spring Scale = 97 Lb. per In.

FIG. 2 (BELOW)—TYPICAL INDICATOR DIAGRAMS OBTAINED WHEN OPERATING A 3 X 4-IN. ENGINE AT 1000 R.P.M.

The Diagrams at the Left Show the Characteristics When Operating with the Compression Pressure Constant at All Loads; Those at the Right Show the Characteristics When Operating with a Fixed Clearance-Space



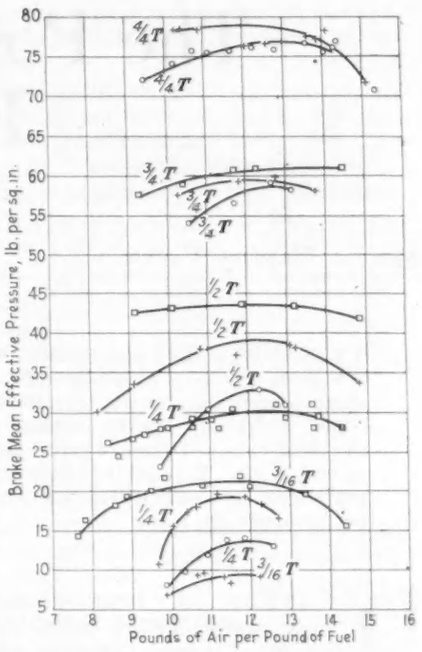


FIG. 3 (UPPER LEFT)—INDICATED MEAN EFFECTIVE PRESSURES OBTAINED FROM INDICATOR DIAGRAMS AT DIFFERENT AIR-FUEL RATIOS AND AT DIFFERENT THROTTLE-SETTINGS

FIG. 4 (UPPER RIGHT)—BRAKE MEAN EFFECTIVE PRESSURES OBTAINED AT DIFFERENT AIR-FUEL RATIOS AND DIFFERENT THROTTLE SETTINGS

(*T*) Throttle Setting. (□) Constant-Compression, Variable Spark. (+) Constant Clearance, Variable Spark. (°) Constant Clearance, Fixed Spark

Comparisons of Performance

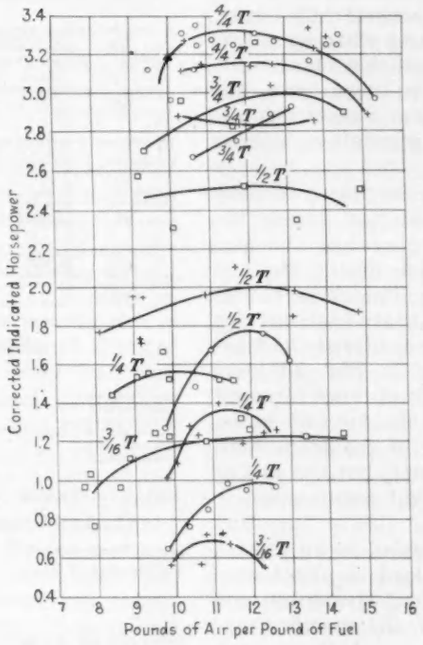
When considering the performance curves, it should be noted that three operating conditions were investigated at 1000 r.p.m. The curves identified by the open square were with constant compression and variable spark; by the cross, with constant clearance and variable spark; and by the open circle, with constant clearance and fixed spark.

In general, all our present engines operate under constant clearance and fixed spark at any one speed, there being no provision for advancing the spark with decreased load. Such increase of spark results in some gain, as will become evident. With constant-compression operation, the spark setting was often varied considerably; but this seemed not to have any particular effect on the engine operation or output. Therefore, it was concluded that a single ignition-setting was entirely sufficient under such operating conditions at any one speed. The spark would need to be changed with change in speed, as is conventional. The air-fuel ratio was changed over a considerable range under each operating condition, which was deemed necessary because it shows the best ratios to use in the several operating conditions.

Fig. 3 shows the curves of indicated mean effective pressure (i.m.e.p.), and Fig. 4 illustrates the brake mean effective pressures (b.m.e.p.). It will be noted that the runs at full (4/4) throttle give substantially the same results whether a fixed spark of 30-deg. advance or slightly less, say a minimum of 23 deg., was used. At ¾ throttle, the constant-compression curves have a higher peak. Steady operation was obtained at air-fuel ratios from one to two units higher than under the other two operating conditions. At ½ throttle, the constant-compression curves peak at 67.5 lb. per sq. in. i.m.e.p. and at 43 lb. per sq. in. b.m.e.p. At constant clearance, the same as that used at 4/4 throttle, and at fully advanced spark, about 40 to 45 deg., the peaks come at 57 lb. per sq. in. i.m.e.p. and at 39 lb. per sq. in. b.m.e.p. At constant clearance and with the spark set at 30 deg., the peaks are at 48.5 lb. per sq. in. i.m.e.p. and at 33 lb. per sq. in. b.m.e.p. At ¼ throttle, the peaks are 42 and 30, 34½ and 19, and 26 and 13 lb. per sq. in i.m.e.p. and b.m.e.p. respectively. At 3/16 throttle, it was found impossible to operate with the constant compression and a 30-deg. spark-advance, so the comparison is between the first two conditions only. The peaks are at 35 and 21½ lb. per sq. in. with constant compression, and at 18½ and at 9 lb. per sq. in. with constant clearance and full spark-advance, for i.m.e.p. and b.m.e.p. respectively. It should be noted that the runs at ¼ throttle with constant compression were not carried out to use as lean mixtures as possible, since only the peak appears on the curve.

Figs. 5 and 6 show the same relations as the foregoing, since the indicated and the brake horsepower are directly proportional to the indicated and the brake mean effective pressures. The data for Fig. 7, which shows the variation in the combined friction and pumping losses, were determined by the motoring method. The values compare very well with differences such as were found between the indicated and the brake horsepowers. They are slightly lower, in general, because the friction losses should be lower with no explosions occurring in the cylinders. Fig. 8 shows that the mechanical efficiency of the engine is higher with constant-compression operation than under the other conditions, the gains being greatest at the lighter loads.

Fig. 9 illustrates the variations in thermal efficiency. Fig. 10 shows the variation in the specific fuel-consumption. At 4/4 throttle, the highest thermal efficiency was 20 per cent. At 3/16 throttle and constant compression, the peak is 14.3 per cent, a value almost as high as that at constant clearance, variable spark and ½ throttle, which curve peaks at 15.6 per cent. This value, 14.3 per cent at 3/16 throttle and constant compression, is



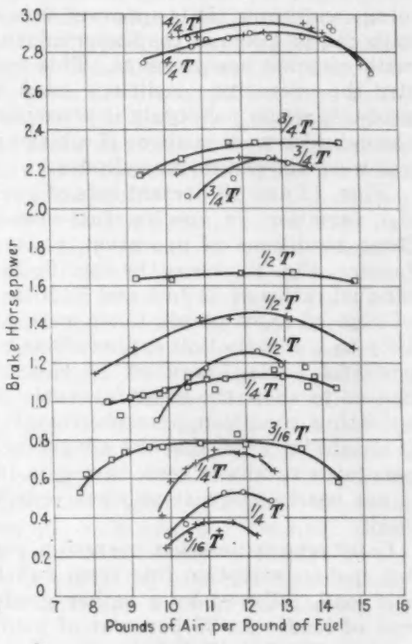


FIG. 5—INDICATED HORSEPOWER OBTAINED FROM INDICATOR DIAGRAMS AT VARIOUS AIR-FUEL RATIOS AND DIFFERENT THROTTLE-SETTINGS

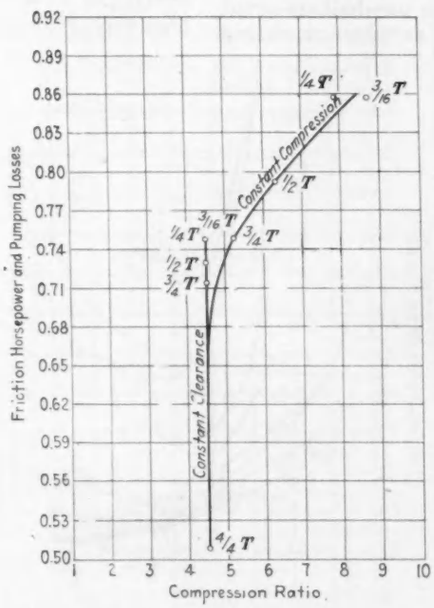


FIG. 7—FRICTION AND PUMPING HORSEPOWER OBTAINED BY THE MOTORING METHOD

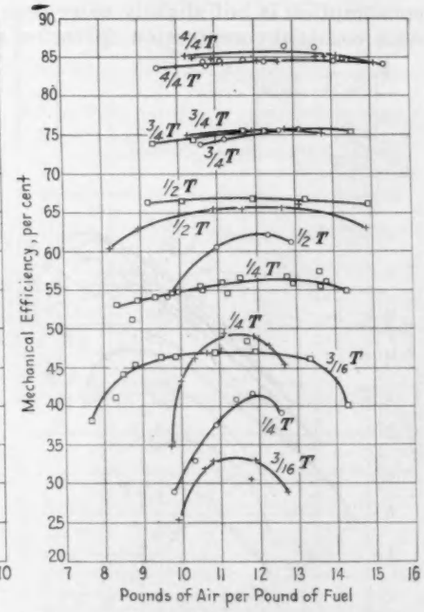


FIG. 6—BRAKE HORSEPOWER OF THE ENGINE AT VARIOUS AIR-FUEL RATIOS AND DIFFERENT THROTTLE-SETTINGS

FIG. 8—MECHANICAL EFFICIENCY

The Curves Illustrate the Ratios of the Brake Horsepowers to the Indicated Horsepowers, as Obtained by the Indicator

(*T*) Throttle Setting. (□) Constant-Compression, Variable Spark. (+) Constant Clearance, Variable Spark. (°) Constant Clearance, Fixed Spark

higher than the value of 12.8 per cent which was obtained with fixed spark-advance and ½ throttle with constant clearance. These figures, 15.6 and 12.8 per cent, show the great advantage of increasing the spark advance as the load is decreased, and the even greater advantage of using constant compression.

Fig. 11 is a chart showing the range of air-fuel ratios over which it was found possible to obtain steady-running conditions. It is apparent that considerable advantage can be taken of the leaner mixtures when operating with constant compression. This condition obtains under the operating conditions used in these tests, and probably would not obtain if attempts at stratification in the cylinder were made or if a large percentage of inert gas were allowed in the cylinder.

Figs. 12 and 13 present sets of curves drawn to show the variation in specific fuel-consumption under the three conditions of operation, plotted against the load factor. Fig. 12 shows the specific fuel-consumptions at air-fuel ratios of 11 to 1 and 12 to 1. The upper curves of Fig. 13 show points taken with an air-fuel ratio of 12½ to 1, a ratio that ordinarily is considered the most powerful. The lower set of curves in Fig. 13 were plotted to show the most favorable conditions for each operating condition, irrespective of the air-fuel ratio. It should be noted that the advancing of the spark with part loads results in some saving in fuel; but the saving is not nearly so great as when constant compression is used.

Constant-compression operation results in an almost flat fuel-consumption line from full load to about one-half load, followed by a rather gradual rise to 20 per cent of load. At 35 per cent of load, the specific fuel-consumption is but slightly more than one-half as great with constant-compression operation as when operating exactly as all automobile engines now operate. It seems that such reduction in fuel consumption would be greatly desired, especially since crankcase dilution and carbon formation are also greatly reduced because of the better combustion characteristics. It was also found much easier to start the engine with constant compression at part-throttle settings than under conventional conditions.

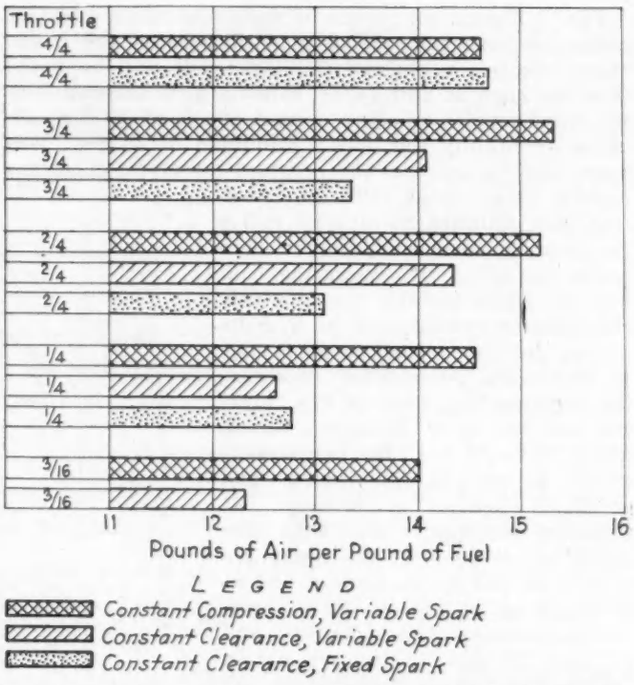


FIG. 11—RANGE OF AIR-FUEL RATIOS OVER WHICH THE ENGINE WAS OPERATED WITH EACH OPERATING CONDITION

Note That with Constant-Compression Operation the Engine Could Be Operated Steadily with a Leaner Mixture Than When Operated Otherwise

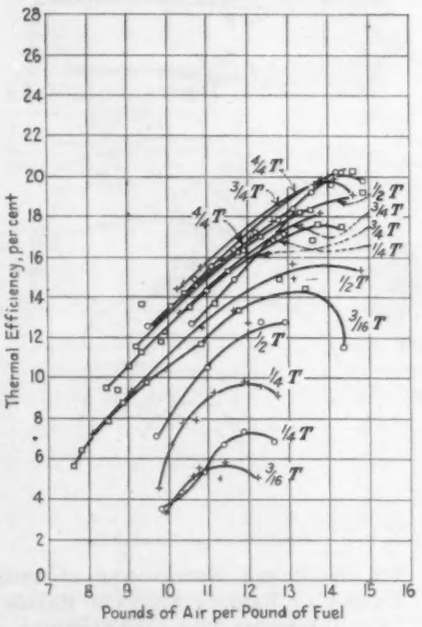


FIG. 9—THERMAL EFFICIENCY

Note That the Runs at 3/16 Throttle and Constant Compression Show Higher Values than Those Obtained by the Conventional Method at ½ Throttle, and That All Values at Constant Compression Are Nearly as High as at Full Load and Full Throttle

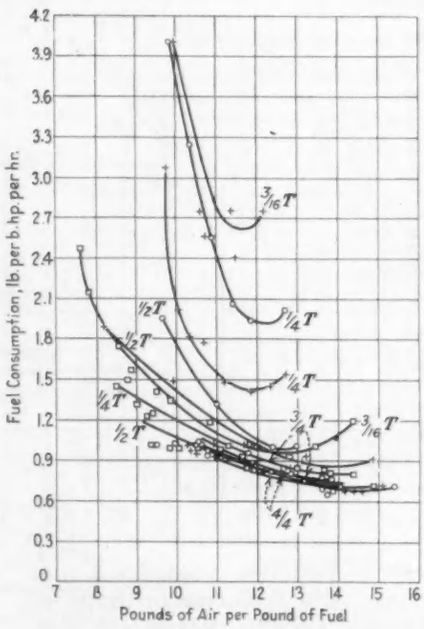


FIG. 10—SPECIFIC FUEL-CONSUMPTION

The Curves Show That Constant-Compression Operation Gives a Low Value at All Loads

(*T*) Throttle Setting. (□) Constant-Compression, Variable Spark. (+) Constant Clearance, Variable Spark. (°) Constant Clearance, Fixed Spark

Theoretical considerations have always indicated precisely the results obtained in these tests. I am not advocating any particular scheme for obtaining these results, although several inventors have written to me during the last year concerning their particular schemes. It is almost obvious that all schemes to attain these results will add something to the cost of an engine. Whether the additional cost is justified remains to be determined by the actual construction of an engine wherein the clearance space is automatically controlled. This can be accomplished by a relatively simple means.

At first thought, it seems that the two-stroke-cycle engine would lend itself to such development, since it is inherently a constant-compression type. But the high combustion efficiency obtained in these tests probably would be difficult to obtain

because of the relatively large amount of inert gas in the charge at light loads in these engines. Some scheme of stratification probably would need to be developed. The attainment of true stratification seems almost impossible, judging from the experience of H. R. Ricardo and others. Mr. Ricardo obtained exceptional results from his first attempt but admitted having had considerable difficulty when he tried other sizes of engine.

Results Applied to a Car

Fig. 14 shows the relative performance of a car fitted with an engine operating under the various conditions stated. The maximum-horsepower car-speed curve of the engine was first plotted. This maximum power is available under all the operating conditions. The curve showing the engine power required on a level concrete road in still air was then plotted. The assumptions made in preparing this curve seem reasonable, since the actual maximum car-speed and the calculated maximum car-speed coincide at 68 m.p.h. Plotting the ratios of the required power to the engine power results in the load-factor curve shown in the upper portion of Fig. 14. The specific fuel-consumption at the several load factors was then taken from the lower part of Fig. 13 for the several conditions of operation, and was reduced to miles per gallon as is shown in the center set of curves in Fig. 14. These curves show that the advancing of the spark at part loads results in a gain of 1½ to 2 miles per gal., and that constant compression results in a maximum gain of about 8 miles per gal. The percentage gains under variable-spark and constant-clearance operation were then calculated, using conventional operation as a basis. The maximum gain owing to variable-spark operation is 18 per cent, and the average gain is about 10 per cent. Constant-compression operation results in a maximum gain of 68 per cent, which decreases to 50 per cent at a speed of 40 m.p.h.

I realize that this comparison is open to criticism because the fuel-consumption characteristics at one engine-speed have been applied throughout the whole speed-range. But I believe that the relative gain would be very nearly the same if data were available. It seems necessary actually to construct such an engine to derive an exact comparison. One inventor says he obtained an average gain of 40 per cent with a rebuilt engine operating nearly as we operated this engine; so, the premise is not entirely without justification.

It seems that active experimentation along the line of increasing fuel-economy would be in order. The possible aggregate savings to owners would be very great, and the consideration of the possible conservation of our visible petroleum stock would be of vast importance. If our 25,000,000 cars each operate 6000 miles per year at an average fuel-consumption of 15 miles per 20-cent gal., and the gain due to constant compression were but 20 per cent as an average, $400,000,000 would be saved per year by the owners. If the gain were 40 per cent, the saving would total $800,000,000 per year. Such savings in our natural resources should be very attractive, and the individual owner's savings also would assist in the selling of motor-vehicles. It is my opinion that this individual saving, say $16 to $32 or possibly more per car per year, would pay in less than one year for the additional material and labor required to install such a scheme on automobile engines. This would not result in any decrease in accelerative ability, because the same maximum power would be available. Possibly there would be an actual gain in accelerative ability, as the engine always would be operating at maximum efficiency without the present tendency to foul on account of faulty combustion; therefore, in the long run, we would obtain better average performance.

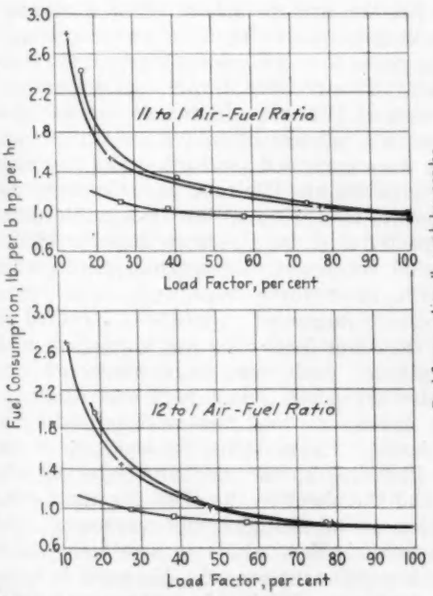


FIG. 12—SPECIFIC FUEL-CONSUMPTION PLOTTED AGAINST THE LOAD FACTOR OF THE ENGINE FOR AIR-FUEL RATIOS OF 11 TO 1 AND 12 TO 1

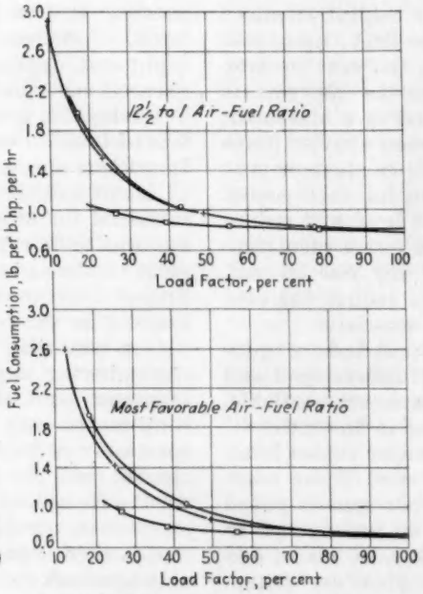


FIG. 13—SPECIFIC FUEL-CONSUMPTION LOAD-FACTOR CHARACTERISTICS WITH A 12½-TO-1 AIR-FUEL RATIO AND FOR THE MOST FAVORABLE POINTS UNDER EACH OPERATING CONDITION

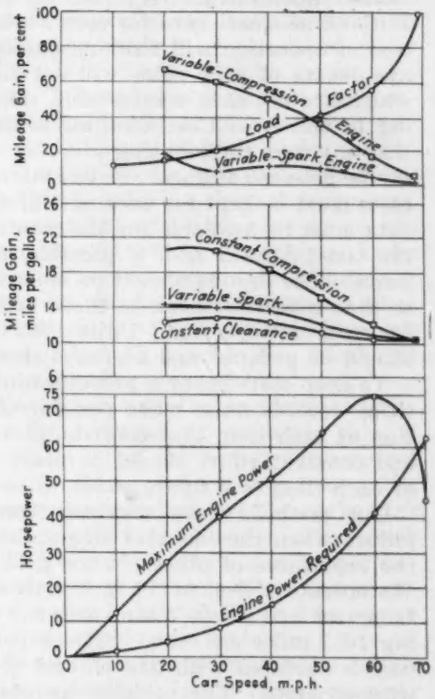


FIG. 14—APPLICATION OF THE DATA TO AN ACTUAL CAR

The Gains Due to Advancing the Spark with the Conventional Engine, and When Using Constant Compression, Are Shown. Note the Great Relative Gain of 50 Per Cent and More at Speeds below 40 M.P.H. When Using Constant-Compression

Motorcoach-Fleet Maintenance

By Carroll C. Humber[1]

Northwest Section Paper

METHODS of operation and maintenance pertaining to a small fleet of motorcoaches are described by the author, who outlines the development of this transportation service from July, 1922, when operation was begun. An inspection system was inaugurated in which due consideration was given to the type of equipment, the nature of the service performed, average loads, the speed maintained, and the nature of the roadway over which the vehicles traveled. In this manner preventive-maintenance methods were put into effect, the results being a steady increase in efficiency.

In the author's opinion, itemized costs must be kept for each unit of the fleet so that the data will be available for the month, the year to date, the last full year and, if possible, for the last several years. The figures should be embodied in a statement so that comparison can be made between similar items for each unit operated. Units differing in make or type should be grouped and averages shown for each group. Details of the inspection procedure for the different parts of the vehicle are given, these being on a mileage basis.

The author states that the regularity and thoroughness of lubrication determine largely the length of life of a motor-vehicle unit. Mechanical repairs are made by the company in its own shop, except that it has been found more economical to have shafts and pistons ground in an outside shop specially equipped for that work and for the repair of electrical units. In conclusion it is remarked that successful maintenance depends upon the operator's knowledge of his equipment and its reasonable possibilities of service, and also upon the choice of competent employes and leadership along a carefully prepared course.

In the discussion, further details are given of inspection methods, and it is stated that depreciation is calculated on the basis of a 5-year period. Some details of performance of aluminum-alloy pistons, as compared with cast-iron pistons, are given.

DETAILED monthly cost sheets and reactions reported by the riding public indicate whether maintenance requirements are being neglected. Without adequate care for motor-vehicle equipment, the cost of operation will rise and patrons having an average degree of civic pride will not ride in motorcoaches which are not safe, comfortable, clean, quiet and pleasing to the eye. Cost accounts must be subdivided so that any item contributing to a rise in cost of operation can be detected at once. To be entirely helpful, itemized costs must be kept for each unit of the fleet; these cost data must be available for the month, the year to date, the last full year and, if possible, for the last several years. The figures should be embodied in a statement so that comparison can be made between similar items for each unit operated. Units differing in make or type should be grouped and averages shown for each group.

To keep costs below a predetermined level and reduce them, records must make possible the quick identification of each item that contributes to any rise in cost, and constant effort should be made to reduce the cost of each item to a figure which is not excessive.

Our methods have resulted from cut-and-try procedure when the industry was rather undeveloped and the experience of others in the field was not available. We operate a fleet of 13 motorcoaches in the cities of Longview and Kelso, Wash., over five major routes totaling 16¼ miles one way. Fifteen per cent of the roadway is surfaced with gravel, and 85 per cent is paved with concrete. The vehicles operate an average of 19 hr. daily, the total annual mileage is 500,000 miles, and more than 1,000,000 passengers per year are transported.

The service was begun in July, 1922, with two motorcoaches. Within six months, six motorcoaches were operating over gravel-surfaced roadways which became next to impassable each time it rained. It was continuously necessary to replace broken springs, axles, frames, wheel bearings, worn brake-drums and linings, worn steering and drive-line bearings, and bushings. By the summer of 1923 the fleet had increased to comprise more than 150 units, including tractors, cranes, shovels and other types of automotive machinery. Troubles were so numerous that we instituted an inspection system for the motorcoaches, using a mileage basis. Complete inspection of the units was made each night and, during operation, all under-floor points were greased each hour. The trouble diminished somewhat.

During the spring of 1924 we adopted a complete system of inspection, on a mileage basis, with maintenance. Inspection sheets were compiled for each make and type of motor-vehicle equipment. Mileage periods were established for all units operating where reasonable mileage was to be expected and, for the miscellaneous equipment, a time period was used. Inspection sheets were turned over to the shop force with only such items checked as were to be inspected. This was handled in such a way that the shop force was not burdened with remembering anything; each item to be inspected *was* inspected, and also adjusted. Any part not likely to continue in safe operation until the next periodic inspection was replaced. Every item checked out, if inspected, was checked back by the mechanic who did the work. He delivered the sheet to the shop foreman, who made such notation as he thought was necessary, and it was then sent to the office, where it was filed under unit headings for a permanent record. No records were kept by the shop foreman. With this system, our costs immediately dropped 2 cents per mile. The equipment was always ready for immediate service, or we knew that it was not ready, and the uncertainty of not knowing when a unit was likely to fail was eliminated. We

[1] M.S.A.E.—Transportation superintendent, Longview Public Service Co., Longview, Wash.

use practically the same system at present, although changes were made from time to time on account of changed conditions or to effect greater economy.

Two first-class mechanics and one helper are employed in our shop during the day and one greaser at night. About 40 per cent of our work is other than motorcoach maintenance. We do all of our mechanical work except overhauling electrical units and grinding shafts and pistons, which work is sent to shops that specialize in it.

Preventive Maintenance a Feature

Experience has indicated that this inspection system is a great preventive of unforeseen delays to equipment. The time required is approximately 128 hr. per 100,000 miles, and the wage cost is approximately $96 for that mileage. At first, inspections consumed considerable time and disclosed conditions which necessitated many major repairs on account of the severe nature of the service; but the men soon became accustomed to the system and were able to make casual inspections with much exactness.

Every fleet operation with which I am familiar differs from others, and no standard system of inspection and maintenance would apply to all alike. Development of a suitable system is a problem that each fleet superintendent must solve if strict economy and efficiency of operation are to be attained. In such an analysis due consideration must be given to the type of the equipment, the nature of the service performed, the average loads, the speed to be maintained, and the nature of the roadways over which the vehicles travel.

Our inspection system is designed to care for our particular conditions as to the character of the service and the type of equipment used. Vehicles that operate over gravel-surfaced roads require much more frequent attention than those running on pavement. Our inspection periods differ for each type; one type of road is mostly smooth and free from dirt, and the surface of the other, wet or dry, is being constantly thrown up against all under-floor points and causes rapid wear. A sample inspection-sheet is shown as Fig. 1.

Clutches are inspected after each 1000 miles in the case of graveled-road operation and each 2000 miles if the operation is on pavement. If wet, the clutch is drained and examined for clearance, the condition of bearings and faces, and the amount of pedal travel; it is also tested for slippage.

Differential cases are drained and inspected after each 20,000 miles, and a full inspection is made of the rear-axle assembly. Virtually the same process is gone through with during the inspection of all units; they are inspected for physical condition, adjustments are made and they are lubricated. Any part which we do not believe will continue to operate with entire safety until the next inspection is replaced, keeping in mind the necessity for as great a length of life as is consistent with good service and economy. This period, which originally was after each 1000 miles, gradually has been extended to 20,000 miles and this year will be made 25,000 miles unless something unforeseen happens. The same procedure is followed in the inspection of the transmission, which was a 1000-mile item at first but is now inspected each 25,000 miles; and this mileage interval will be increased to 30,000 miles this year.

The engine, including the fuel system, cooling system, ignition and starter, is casually examined after each 5000 miles without dismantling to determine whether every part is tight and normal. No actual work is done or replacement made until the efficiency of the engine is known to be decreasing. If the engine is not noisy and the gasoline and oil-consumption mileages are up to a predetermined average, we leave it alone. If the piston-rings become sloppy and the valves leak, the gasoline and oil-consumption mileage-averages will decrease. If carbon accumulates to the extent that it causes the engine to knock, it is due only to oil pumping or a rich mixture, both being indicated if the records are kept correctly. We have no set time for the replacement of piston-rings. We have found it necessary to replace some after less than 10,000 miles; some have gone in excess of 60,000 miles, with a loss of less than 5 per cent in the fuel and oil performances. Our average for several years is above 25,000 miles.

Formerly, valves were ground after each 2000 miles and, at a later time, at 3000 and 5000 miles; now, they are ground only if the record indicates that they need it or when the engine is opened up after about each 15,000 miles for carbon removal.

We keep very strict records of gasoline and oil-consumption mileages, and these are summarized the first of each month. If the average decreases as much as 4 per cent during any month, we find out why and remedy the condition. We also refer to the gas and oil-consumption records daily, at which time the consumption for the previous 24 hr. is posted.

Causes of Inefficient Performance

We do not always discover the cause of inefficient gasoline and oil performance in the engine cylinders, but it is almost always indicated gradually by the performance. Sometimes the ignition system, and many times the carbureter, is at fault. Faulty condensers, pitted breaker-points, defective insulation on high-tension wires, weak magnets, faulty armatures, worn jets and control valves all contribute to high fuel-consumption averages. We have had only two cases of excessively high fuel-consumption during the last four years. In one instance the engine of a 25-passenger coach, the average fuel-consumption of which was 9.2 miles per gal. for the previous 12 months, was reconditioned; it then averaged 13.4 miles per gal. for 1652 miles, when the head of No. 1 exhaust valve broke. The valve was replaced, but after another 1500 miles No. 4 exhaust valve broke. The carbureter was replaced with one taken from a similar coach and the fuel consumption for the next 6000 miles averaged 9.1 miles per gal. It was found that the main jet of the carbureter removed should have been a No. 22 jet but actually was a No. 24 jet. A No. 22 jet was installed and the carbureter replaced on the coach to which it belonged, after which the fuel consumption averaged 9.1 to 9.3 miles per gal. The men who had driven this coach after it was reconditioned had not noticed that anything was wrong with it, and two of them could be termed expert drivers.

The cause of low oil-consumption mileage is nearly always found in the cylinders. It is not necessarily caused by a condition of the piston-rings or by wall taper but by the pistons. For example, the engine of a 25-passenger coach was reconditioned; the cylinders were rebored and honed, and then fitted with aluminum-alloy pistons of a late design that were ground to the manufacturer's specified clearances. Plain snap-rings were used, and an oil-control ring was installed be-

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The intention of this inspection is to assure the safe operation of this unit for another 3000 to 5000 miles. Any parts or material that will not, with entire safety, stand up for that period of time must be replaced.

I am satisfied that a thorough examination of the above numbered coach has been made, that all defects have been remedied and that the coach is in good running condition.

Signed.....
Foreman.

	Work Done by	Condition of Each Unit after Inspection
No. 1—RADIATOR AND HOOD		
(*a*) Examine radiator for leaks		
(*b*) Examine radiator core and shell fastenings		
(*c*) Examine radiator hold-down bolts		
(*d*) Examine hood hold-down clamps		
(*e*) Examine radiator to dash rod		
No. 2—ENGINE		
(*a*) Run engine and examine for knocks		
(*b*) Examine pump, water inlet and outlet, and hoses		
(*c*) Examine for oil leaks		
(*d*) Drain crankcase and clean strainer		
(*e*) Test compression		
(*f*) Examine fan-belt and grease fan shaft		
(*g*) Examine engine hold-down bolts and supports		
(*h*) Examine main bearings		
(*i*) Examine connecting-rod bearings		
(*j*) Examine valves; grind valves		
(*k*) Remove pistons and install new piston-rings		
(*l*) Refill crankcase		
No. 3—IGNITION		
(*a*) Clean and inspect magneto		
(*b*) Clean and adjust breaker points		
(*c*) Oil bearings		
(*d*) Test all wires and tubes		
(*e*) Clean and adjust spark-plugs		
(*f*) Examine ground switch and wire		
No. 4—CARBURETER		
(*a*) Remove jet caps and clean wells		
(*b*) Examine float, weights, and clean screen		
(*c*) See that manifold connection is O. K.		
(*d*) Examine fuel line and clean sediment bulb		
(*e*) See that tanks are secure and that the line is not rubbing		
(*f*) Examine throttle cross-shaft and pins		
No. 5—CLUTCH		
(*a*) Examine clutch and throw-out bearings		
(*b*) Test for slippage and clearance		
(*c*) Wash out and refill		
No. 6—TRANSMISSION		
(*a*) Test for noise		
(*b*) Drain and examine gears		
(*c*) Examine bearings for lift and thrust		
(*d*) Refill to correct level		
(*e*) See that shifting bars are properly dogged		
(*f*) Examine hand-brake ratchet and dog		
No. 7—PROPELLER-SHAFT		
(*a*) Inspect shaft and universals		
(*b*) Inspect driveshaft center-bearings		

	Work Done by	Condition of Each Unit after Inspection
No. 8—REAR AXLE AND BRAKES		
(*a*) Jack up rear end and see if both wheels are free		
(*b*) Test for lift and lateral motion in bearings		
(*c*) See that wheels are tight on taper or shaft		
(*d*) See that brake-drum bolts are tight		
(*e*) See that felloe bands are O. K.		
(*f*) Examine rear-spring clips		
(*g*) Examine rear springs		
(*h*) Drain differential and inspect bearings		
(*i*) Inspect gears and pinion		
(*j*) Inspect rear-wheel bearings and locks		
(*k*) Grease rear-wheel bearings		
(*l*) Refill differential		
(*m*) Inspect and adjust service brakes		
(*n*) Inspect and adjust hand brake		
No. 9—FRONT AXLE, STEERING AND FRONT SPRINGS		
(*a*) Jack up front end and test bearings for wear		
(*b*) Check wheels for toe-in and camber		
(*c*) Grease front-wheel bearings		
(*d*) Examine tie-rods and drag-link		
(*e*) Inspect spindle bolts and bushings		
(*f*) Inspect front springs and spring clips		
(*g*) Inspect steering-gear		
(*h*) See that bracket is tight		
(*i*) See that all nuts are pinned		
(*j*) See that the steering-column is secure and tight		
(*k*) Grease steering-gear and all pins		
(*l*) Inspect speedometer head, chain, swivel and gears		
(*m*) Grease speedometer swivel and chain		
No. 10—ELECTRICAL		
(*a*) Remove and inspect generator		
(*b*) Check output and oil bearings		
(*c*) Remove and inspect starter motor		
(*d*) Oil starter motor		
(*e*) Inspect all lights and see that they are clean		
(*f*) Inspect signal system		
(*g*) See that all connections are tight at the switch		
No. 11—TIRES		
(*a*) Dismount and inspect all tires that have not been dismounted within two weeks		
(*b*) Inflate all tires to correct air-pressure		
No. 12—BODY		
(*a*) Examine windshield cleaner		
(*b*) Inspect for loose seats and windows		
(*c*) Examine body hold-down bolts		
(*d*) See that fenders and bumpers are tight		
(*e*) Test fire extinguisher		
(*f*) Test heating system		
(*g*) See that cushions are in good condition		
(*h*) Test driver's door-control		

Nos. 1 to 4 inspections are made each 5000 miles; time required, 1 hr. 30 min. No. 5 is made each 2000 miles; time required, 30 min. No. 6 is made each 20,000 miles; time required, 1 hr. No. 7 is made each 5000 miles; time required, 30 min. No. 8 is made each 20,000 miles; time required, 4 hr. 30 min. No. 9 is made each 5000 miles; time required, 1 hr. No. 10 is made each 10,000 miles; time required, 1 hr. 30 min. No. 11 is made each two weeks. No. 12 is made each 25,000 miles; time required, 30 min.

FIG. 1—MOTORCOACH-INSPECTION SHEET

neath them. The oil consumption of this engine for the preceding year had been 102 miles per qt., but it immediately became 56 miles per qt. and remained almost at that average for 8000 miles. Then the pistons were replaced with new ones of the same type that had been in the engine for 135,000 miles, although the old rings which had been removed were used. The oil-consumption mileage immediately increased and the average became higher than for the preceding year.

Exceptionally heavy work in 1922 and 1923 necessitated a great amount of low-gear and second-gear operation that caused considerable main-bearing and connecting-rod-bearing trouble. The bearings did not burn out but became loose. Use of different brands and grades of oil did not correct this trouble, and aluminum-alloy pistons were installed in the engines of two 5-ton gravel-carrying trucks. That ended the bearing trouble and, before the end of 1923, we changed almost entirely to aluminum-alloy pistons. The period between reboring cylinder-blocks was extended from approximately 50,000 miles to be more than 150,000 miles in motorcoach service, and the life of pistons has in some cases exceeded that mileage.

In this same type of equipment we have crankshafts which have operated more than 225,000 miles without having had the main bearings adjusted except at the time of engine overhaul. The crankpins have not been ground and the connecting-rod bearings have been taken up only at the time of piston-ring installation. These four-cylinder 56-hp. engines are installed in 25-passenger coaches that weigh 9860 lb. and on which the oil-consumption mileage has exceeded 100 miles per qt. during their entire life of more than 240,000 miles. They are not equipped with either air-cleaners or oil-filters. The oil is changed after each 666 miles. The average life of piston-rings has been more than 40,000 miles, and the gasoline and oil-consumption performances have not decreased more than 4 per cent at any time, except in the case mentioned.

Engine and Other Reconditioning

Our method of reconditioning an engine is to rebore and hone the cylinders and install aluminum-alloy pistons having a diametrical clearance of 0.001 in. for each inch of piston diameter. A quick-seating type of piston-ring is used, and the circumferential clearance is 0.002 in. An oil-control ring is installed on the bottom, and it is bled with eight 3/32-in. holes in the lower edge of the groove. The crankshaft, pistons and piston-rings are assembled in the block and run-in for 8 hr. The assembly is then dismantled and the parts washed; next the engine is assembled and run-in under its own

TABLE 1—OPERATION AND MAINTENANCE COST AND OTHER DATA FOR MARCH, 1929

	Cost, Cents per Mile, for Motorcoach No.													Cost		Average Cost, Cents per Mile	
	1	2	4	6	7	8	9	10	11	12	14	15	16	March	Total March To Date		
Operation																	
Gasoline	1.19	2.71	1.71	2.08	1.83	3.06	3.43	1.50	1.53	1.96	1.45	1.65	2.21	$755.50	$2,540.78	2.02	2.01
Lubrication	0.19	0.72	0.26	0.36	0.16	0.24	0.15	0.06	0.28	0.31	0.31	0.31	0.24	117.82	500.42	0.27	0.37
Cleaning	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	94.60	266.97	0.22	0.22
Greasing	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	94.49	154.27	0.22	0.22
March Cost	..	..	..	..	..	..	..	..	..	..	..	..	..	$1,062.41	$3,562.44	..	..
March Cost per Mile	1.82	3.87	2.41	2.88	3.43	3.74	3.99	2.00	2.25	2.71	2.20	2.40	2.89	.....	.....	2.73	..
To Date Cost per Mile	2.39	3.12	2.81	2.98	2.92	3.73	3.60	3.83	3.05	2.87	2.64	2.72	3.38	.....	.....	..	2.82
Maintenance																	
Body	0.10	0.13	..	..	..	..	1.25	0.20	0.06	0.03	..	0.02	0.14	$20.99	$107.17	0.05	0.08
Engines	0.24	1.08	0.01	1.72	0.52	0.58	2.31	2.60	0.03	0.11	0.28	0.08	1.68	162.29	537.57	0.37	0.43
Chassis	0.12	0.31	0.34	4.96	0.05	0.53	...	0.21	..	0.12	0.24	0.04	..	97.82	352.44	0.22	0.28
Electrical	0.13	0.17	0.01	...	0.14	0.16	0.82	..	0.35	0.48	0.50	0.03	1.86	121.74	344.04	0.28	0.27
Brakes	0.59	0.26	0.07	0.01	0.31	0.11	0.80	0.21	0.10	0.09	..	0.09	..	88.56	282.98	0.21	0.22
Paint	..	..	..	..	..	..	..	..	..	0.20	0.29	0.42	0.88	54.62	79.34	0.13	0.06
March Cost	..	..	..	..	..	..	..	..	..	..	..	..	..	$546.02	$1,704.54	..	..
March Cost per Mile	1.18	1.95	0.45	6.65	1.04	1.39	5.33	3.11	0.57	1.05	1.32	0.68	4.52	.....	.....	1.26	..
Average Cost to Date for Maintenance	2.03	3.15	1.02	7.13	0.99	1.03	5.32	2.40	0.77	0.81	0.78	0.56	2.16	.....	.....	..	1.34
Total March Cost per Mile	3.00	5.82	2.86	0.11	3.47	5.13	9.32	5.11	2.82	3.76	3.52	3.08	7.47	$1,608.43	.....	3.71	..
Total Cost to Date per Mile	4.43	6.27	3.83	9.04	3.91	4.76	9.26	5.36	3.83	3.68	3.42	3.27	5.55	.....	$5,266.98	..	4.16
Mileage	6,740	1,836	4,870	777	6,794	1,505	192	414	5,439	4,294	4,229	4,437	1,752	43,303	.....	..	..
Mileage to Date	..	..	..	..	..	..	..	..	..	..	..	..	..	126,478	.....	..	..
Fuel Consumption, miles per gallon	14.3	6.2	9.7	7.0	9.0	6.0	5.1	11.6	10.7	8.3	11.5	10.0	7.7	.....	.....	9.6	9.3
Oil Consumption, miles per gallon	105	33	81	55	152	107	96	138	68	70	61	66	70	.....	.....	77	67

power for 24 hr. It is then ready for service without any limitations except that, for the first two days, crankcase oil is added to the fuel in an amount equaling 2 per cent by volume. During a total of more than 2,000,000 miles of motorcoach service we have never had an engine seize after reconditioning, and this procedure has been followed consistently.

We have difficulty in determining correctly when to replace the moving parts of a chassis, such as ring-gears. I have never seen a ring-gear worn to the extent of needing replacement, although loss of its case-hardened face necessitates a change. There is no set rule for determining when to discard a worn axle-shaft or a worn gear. We attempt to extend the life of parts as long as possible, keeping in mind that we should not use parts which are worn so much that they make undue noise or contribute to difficulty in handling the vehicle. Usually we do not replace a part except when justified by considerations of greater safety, better control or increased economy of operation; but economy is never subordinated to safety. We attempt to keep steering connections and brakes up to a high standard of effectiveness because our operation is all in traffic and control of the vehicle is essential. During 2,000,000 miles of operation, no vehicle has been out of control on account of any steering or brake troubles.

Adequate Lubrication Essential

The regularity and adequacy of lubrication largely determine the length of life of a vehicle. The correct periods for lubrication must be determined, and the schedule must be followed religiously. Grease and oil are the cheapest preventive-maintenance materials that can be applied to a chassis. The normal life of any given unit can be extended greatly by adequate adjustments and the tightening of nuts, and by sufficient lubrication.

TABLE 2—AVERAGE COST FOR THREE YEARS COMPARED WITH COST FOR 1928

	Cents per Mile	
	1928	Average for Three Years
Operation		
Gasoline	2.32	2.33
Lubrication	0.30	0.30
Cleaning	0.37	0.31
Greasing	0.38	0.30
Total	3.37	3.24
Maintenance		
Engine	0.37	0.41
Chassis	0.50	0.47
Electrical	0.13	0.20
Bodies	0.53	0.29
Brakes	0.23	0.23
Paint	0.15	0.08
Total	1.91	1.68
Grand Total	5.28	4.92
Average Fuel Consumption, miles per gallon	8.6	8.2
Average Oil Consumption, miles per gallon	63	65

The wearing out of a vehicle does not bother us so much as does its obsolescence. We are now completely rebuilding a coach body which has been in service for five years and has operated more than 240,000 miles. The chassis has better than 50 per cent of its original value from the viewpoint of continuing in the same service. We are spending $1,000 on the body and, when finished, we believe the coach will operate for another 200,000 miles with the same efficiency as in the past; but the body is now out of style.

TABLE 3—ROAD DELAYS AND ACCIDENTS

	March	To Date
Road Delays		
Chassis	2	7
Engines	2	10
Electrical	..	1
Tires	2	8
Fuel	..	1
Accident	..	0
Weather	..	3
Traffic	..	1
Drivers	..	8
Total	6	39
Average Number of Miles per Delay	7,216	3,243
Average Number of Miles per Delay for Mechanical Reasons Ouly	10,825	6,656

	No.	Cost	No.	Cost
Accidents				
Drivers' Errors	2	$4.50	5	$27.17
Not Drivers' Errors	1	5.00	5	36.00
Total	3	$9.50	10	$63.17

Good Maintenance Reduces Costs

As a result of using the foregoing methods, our total costs, covering operation and maintenance and fixed costs, have been reduced from 26 cents per mile in 1923 to 16 cents per mile in 1928. Over a three-year period, 1926 to 1928 inclusive, the operating cost for gasoline, oils, greases and the labor of cleaning and greasing, was 3.24 cents per mile or 18.6 per cent of the total cost. The maintenance cost for all materials and mechanical labor was 1.67 cents per mile or 9.7 per cent of the total cost. The total operating and maintenance cost was 28.3 per cent of the total cost. The entire cost for the year 1926 was 1.91 cents per mile; for 1927, 1.64 cents per mile; and for 1928, 1.62 cents per mile, or an average of 1.72 cents per mile for a three-year period. These figures cover all costs. The gasoline and oil-consumption averages for the same period were 8.2 miles per gal. of fuel and 65 miles per qt. of oil. Table 1 shows itemized costs for March, 1929, and the average of these items. Table 2 compares costs for 1928 with average costs for three years. Table 3 shows delay and accident data.

Make your shop attractive to your men, buy the equipment they need to perform the work you expect them to do, work with them, give them the benefit of your experience, and know the difficulties that confront them. A great deal depends upon the judgment of the men who are doing the class of work you expect, and errors in their judgment will come back to you many times multiplied. Success in your work depends upon your capacity to know your own equipment and what its reasonable possibilities of service are, and upon your ability to choose competent men and lead them in a carefully prepared and determined course. If you fail in doing this, your cost sheets will tell you a sad story.

THE DISCUSSION

D. F. GILMORE[2]:—What is your practice at the time of periodic overhaul of the transmission?

CARROLL C. HUMBER:—The unit is dismantled completely and adjusted, the time required being 4½ hr. if no replacements are needed.

H. W. DRAKE[3]:—To what degree of refinement do you carry your cost record?

MR. HUMBER:—Under "operation," the labor and material costs for gasoline, lubrication, cleaning and greasing are charged and, under "maintenance," we charge the items on the chassis, body, engine, electrical system, brakes and painting. We have not thought it necessary to subdivide those items.

QUESTION:—At the periodic inspection of clutches after 2000 miles of operation, have you found excessive wear in the throw-out bearings?

MR. HUMBER:—We have had some difficulty in that respect on some vehicles on which the throw-out bearings are exposed. Vehicles operating over gravel roads are inspected each 1000 miles on this account.

ROBERT S. TAYLOR[4]:—What type of piston do you use?

MR. HUMBER:—We have used a solid type of aluminum-alloy piston for the last 5 years.

JOSEPH H. LYONS[5]:—What is the depreciation basis upon which the length of life of the equipment is calculated?

MR. HUMBER:—I think a motorcoach should render 400,000 miles of service without requiring major replacements. The basis of calculating depreciation is for a 5-year period.

QUESTION:—What is the length of life of the aluminum-alloy pistons and how much wear do they show?

MR. HUMBER:—Some of our pistons have operated more than 150,000 miles. We do not take account of piston wear unless the consumption of gasoline and oil exceeds the average monthly consumption by 4 per cent.

Rigid Lubrication Schedule

MR. DRAKE:—How do you determine the mileage for changing oil?

MR. HUMBER:—Our lubricating schedule is as rigid as is our inspection schedule. The mileage schedule has been worked out on the basis of 333, 666 and 1000 miles so that the labor expense for greasing can be kept at the minimum for each piece of equipment. In connection with the use of our reclaimed lubricating oil, we have found it economical to use the 666-mile basis and our engines are using practically clean oil at all times.

QUESTION:—In your system of inspection, do you use a chart and classify the inspections made with regard to items?

MR. HUMBER:—We have found that it is best for us to include in the engine inspection, for example, all those items which are accessory to the engine, including the fuel and the cooling systems. The separate items include the clutch, transmission, propeller-shaft, rear-axle assembly and the like. Each 10,000 miles, inspection is made of the electrical equipment.

MR. TAYLOR:—How is the brake-inspection period determined?

MR. HUMBER:—When the drivers come off a run they are required to note in a book whether or not the vehicle is in an operating condition. If not, an inspection is made.

Aluminum-Alloy-Piston Performance

A MEMBER:—How do you account for the longer life of the aluminum-alloy pistons? Do they wear the cylinder more or less than cast-iron pistons? Should not the longer life of the aluminum-alloy piston be attributed to slow speed of the schedule rather than to the particular efficiency of that type of piston?

MR. HUMBER:—If our vehicles operated in long-distance service, maintained higher road-speed and had greater engine-speeds, the length of life of the aluminum-alloy piston might not be as great; but I am sure that we have more than double the length of life from these pistons than we obtain from cast-iron pistons.

PROF. F. G. BAENDER[6]:—My experience is that aluminum-alloy pistons wear more rapidly at high speed than do cast-iron pistons. This also has been the experience of other engineers with whom I have talked. In one instance, the aluminum-alloy pistons of a high-class eight-cylinder engine were worn out after 18,000 miles of service of a car which was driven at a very high average road-speed. The ring-grooves became perhaps 1/16 in. wider than the rings themselves. I believe that the aluminum pistons will not stand up as well as cast-iron pistons at high speed.

MR. HUMBER:—We have had some cases of enlarged piston-ring grooves, but we believe this was caused simply by wear. We are using aluminum-alloy pistons in engines which operate at 3000 r.p.m. in normal service and have had very good performance from them.

MR. LYONS:—Under what conditions of cooling are the engines operated at 3000 r.p.m.?

MR. HUMBER:—We attempt to operate engines at a temperature of from 160 to 180 deg. fahr. At the time we had piston trouble we tried various brands and grades of oil and also changed oil more frequently, but we did not overcome the difficulty until we changed to aluminum-alloy pistons. At one time we operated 25 motor-trucks in service that was so heavy that tractors had to be used to help the trucks get through. The trucks operated under very severe heat conditions, but we have never had a case of seizure of aluminum-alloy pistons that had been fitted in our own shop.

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[2] A.S.A.E.—Service manager, Sands Motor Co., Seattle, Wash.

[3] Superintendent of garage and service station, Portland Gas & Coke Co., Portland, Ore.

[4] M.S.A.E.—Seattle, Wash.

[5] A.S.A.E.—Superintendent of operation and maintenance, Tacoma Bus Co., Tacoma, Wash.

[6] M.S.A.E.—Head of mechanical engineering department, Oregon State Agricultural College, Corvallis, Ore.

Automotive Research

The Vital Significance of the Cooperative Fuel Research[1]

By H. L. Horning

FOR SEVERAL years the Society has been working through the Bureau of Standards toward developing constant factors in the problem of vaporization that will aid us in standardizing gasolines and in visualizing what is happening in the engine manifold.

The proper burning of the fuel in the combustion chamber, which a few years ago was a problem of paramount importance, has been almost completely conquered. One of the greatest forward movements in the industry at the present time is the development of improved transmissions and correct transmission-ratios. Perhaps few engineers realize what a tremendous and intricate problem in distribution is involved. To picture the question as a whole, suppose we consider the following formula, known in our shop as the master formula, which accounts for all losses in an engine from the energy of the fuel to the mean effective pressure:

$$A_c \times R_c \times M_c \times V_c \times 557 = BMEP \qquad (1)$$

where A_c is air-cycle efficiency, R_c is relative efficiency, M_c is mechanical efficiency, and V_c is volumetric efficiency. These values, when multiplied together and by 557, give the resulting brake mean effective pressure. A_c and R_c combined give thermal efficiency, and $A_c \times R_c \times M_c$ equals brake thermal efficiency.

It is very easy to measure all these values with the exception of R_c, and with the apparatus that is now available this value is easily calculated. It is not difficult in a four-cylinder engine to get a value of 66 for this factor, or with skill it may reach 68, but in a six-cylinder engine the relative efficiency takes a decided drop, doing well at 54. This indicates the magnitude and importance of improved distribution, for, if the losses are analyzed, it will be found that distribution is the only one outside control. No matter how well designed the combustion-chamber is, what the compression is, or the mechanical efficiency, as long as the distribution is faulty this striking difference in relative efficiency between the four-cylinder and six-cylinder engine will remain.

Basis Needed for Design Improvement

The needed improvement in design which is of paramount interest to the industry must be based on a thorough knowledge of the relation between fuel volatility and engine characteristics. It is the solution of this problem, with its bearing on further development, particularly of the six-cylinder and the eight-cylinder engine, that has prompted the long and tedious researches at the Bureau of Standards.

We must, then, convert the energy of the fuel which is in the liquid form into a vapor, send it into the cylinders, and finally realize it in applied power expressed as brake mean effective pressure. But that is not the entire point; the details of the method by which we do it are very devious and very difficult.

In buying cars, the public demands acceleration, above all other factors. The way the car gets away in traffic is in many instances the greatest measure of satisfaction. In the course of the Cooperative Fuel Research, an apparatus had been developed for measuring acceleration in the laboratory. I believe that, with this equipment, the car companies, improving it in their own way, expressing their own personality, will be able to develop acceleration in the car or in an engine in less than three weeks. It is almost impossible to do this work quickly and promptly in the field and in addition the field test has the disadvantage that so many conditions are beyond control.

There is another feature. It is generally known that gasoline-electric service is the most difficult in the automotive transportation field. No other service destroys engines so rapidly as the gasoline-electric service. But to say that and leave it at that point would be an injustice. Perhaps the basis of this trouble is entirely a matter connected with vaporization and acceleration. Whether the gasoline-electric system is going to be successful in this industry will depend entirely on our better understanding of the fundamentals that have been investigated at the Bureau of Standards.

Importance of the Results

This undertaking has furthermore constituted a unified movement of the petroleum and automotive industries toward a greater value to the public in the utilization of gasolines. Gasoline quality has improved and many cars weighing 5000 lb. are now making the gasoline mileage that the Ford car used to make before this work was undertaken. At the inception of this research a great shortage of fuel was supposed to exist; today, the problem facing the automotive industry is how to cut down the quantity of fuel used per mile. The improvement of miles per gallon in cars, the technique that has been developed to accomplish it, and the change in standard specifications that makes possible a greater yield per barrel of crude are some of the many valuable results.

If any company in the industry desires to put its product on the highest possible plane by developing the highest possible standard, it can do nothing better than to study the reports and publications listed in Dr. Dickinson's paper. If the knowledge contained therein is applied, it will produce the very finest type of car and the greatest car value for the dollars it spends, as well as the car with the lowest maintenance cost.

[1] Remarks by the Chairman of the Research Session at the Semi-Annual Meeting, prior to presentation of Dr. Dickinson's paper and other Bureau of Standards reports.

The Cooperative Fuel Research and Its Results

By Dr. H. C. Dickinson[1]

Semi-Annual Meeting Paper

Herein Dr. Dickinson reviews briefly the causes leading to birth of the Cooperative Fuel Research, the appointment of the joint steering committee to confer on program and pass upon results, the progress made in the several phases of the work. and the projects now engaging attention.

An outstanding feature has been the development of harmony and cooperation among engineers of the petroleum and the automotive industries.

Mutual adaptation of the fuel and the engine to each other has been the guiding principle in the work, to the end of National economy and internal-combustion engine efficiency.

Projects undertaken include the determination of the grade of gasoline that affords the maximum number of car-miles per barrel of crude oil; the causes of and remedies for crankcase-oil dilution; the effect of initial volatility on starting, acceleration and general behavior of the engine; and measurement of the detonating characteristics of a fuel.

A bibliography of the progress reports is given at the end of the paper.

In conclusion, the author emphasizes that this research work already has brought into accord the engineering staffs of the two industries; contributed largely to fuel saving for the Country; developed all the data needed to combat crankcase-oil dilution; provided complete data on the relationship of fuels to engine-starting; cleared up the question of the effect of fuel on engine acceleration; and is now concerned with securing satisfactory control over the relationship between fuels and compression ratios.

GASOLINE was for many years a waste product from the refining of kerosene and contained all the volatile matter that the law of the State and the laws of nature would permit. Up to about 1910 no one complained and gasoline was generally accepted as such.

About this time the demand began to push the supply and the quality began to change. No reliable information was at hand as to the effect of gasoline volatility on engine performance but hot-spots began to appear as part of the engine manifold and there was much discussion of the relative merits of small spots which were very hot and large spots that were not, as well as hot air without hot-spots.

In 1914 a general conference was called jointly by the Bureau of Standards and the Bureau of Mines to consider the question of a National interpretation of what constituted gasoline, or in short a definition of gasoline. This proposal met with a storm of protest from the petroleum industry, but shortly thereafter war distracted attention from such minor matters as gasoline definitions and specifications. When conditions became more settled after 1918, complaints concerning gasoline grew louder. There were charges and countercharges, claims and counter-claims between the technical men in the automotive and petroleum industries. Still there was no real information, worthy of the name, as to how the fuel behaved in the engine or what either industry might properly expect or demand of the other.

At this stage of the controversy and after numerous attempts to secure some sort of accord, the Cooperative Fuel Research was born. This began and has continued as a sort of four-sided combine. The National Automobile Chamber of Commerce and the American Petroleum Institute, representing the two industries, furnished the funds. The Society of Automotive Engineers undertook to administer the funds and watch the technical program, and the Bureau of Standards undertook to carry on most of the research work supplemented by the Research Department of the Society. A joint steering committee was appointed to confer on program and pass upon the results.

The earlier conferences developed much divergence of opinion between the two groups; in fact, controversy was the order of the day. This condition, however, was soon changed. Harmony and cooperation among the members of the steering committee and the engineers of the two industries has become an outstanding feature of the project. Better cooperation between interests so diverse would be hard to find.

One development which probably has been influenced to a large extent by the contacts between automotive and petroleum engineers in connection with the cooperative fuel research, is the establishment of fuel-research laboratories by most of the larger oil companies. In 1922 there was not, so far as we know, a single laboratory in the petroleum industry, and perhaps only one or two in the automotive industry, equipped for effective study of the relationship of fuel characteristics to engine performance. Today few large companies in the oil industry are without such laboratories and at the present rate soon there will be none.

The cooperative fuel research has had for its one guiding principle the mutual adaptation of the fuel to the engine and the engine to the fuel, to the end of National economy and efficiency. The several individual projects which have been undertaken, completed and reported in committee and at general meetings of the Society and the American Petroleum Institute for the last six years have had for their aim this one objective. Most of these results are doubtless known to all readers of The Journal, hence they are referred to here only briefly.

Under this joint arrangement, the first project under-

[1] M.S.A.E.—Chief, heat and power division, Bureau of Standards, City of Washington.

taken was to determine what was the best gasoline as regards volatility, considered on a broad economic basis; in other words, what grade of gasoline would afford the maximum number of car-miles of transportation per barrel of crude oil used in its production. This question obviously could not be answered in the laboratory alone. It did not suffice to know how much more efficiently an ideal engine in the laboratory could be run on one fuel than on another; it was necessary to know how much more of one kind of fuel than of another the average driver would use on the road. This difference multiplied by the total number of cars in the Country might be expected to give the difference in National consumption of the two fuels. This figure, together with an estimate of the difference in cost of the two fuels, would answer the question.

The problem was attacked from two angles; first, four test fuels designated *A*, *B*, *C* and *D*, covering the practical range of volatilities, were specified for experimental purposes and made up in quantity by two refineries, one in the Mid-West and one in the East. For the first angle of attack, passenger cars of four types were selected, these four types representing about 75 per cent of the total number of cars in service in the Country at that time. One used car of each type, which had been run from one to two years, was secured for a test program at the Bureau of Standards. These cars were put through a most exhaustive series of tests for average fuel consumption with each of the four different fuels under road conditions. The details of this program were carefully considered by the steering committee as well as by the Bureau of Standards staff to be sure that the results would be truly typical of average driving conditions. The program consisted of one series of tests in summer with all four cars and another complete series in winter with two of the cars.

For the second angle of attack, which was put through mainly by the Research Department of the Society, 10 automobile manufacturing companies were enlisted in two road-test programs, one run in summer and another in winter. Each company selected a group of 4 to 12 cars driven in regular service by members of its staff, and purchased enough of the four test fuels to supply the group of selected cars for at least four weeks. Each of these cars was supplied with one of the experimental fuels for one week, another for the second week, and so on, according to a carefully prearranged program designed to average-out weather conditions and individual differences. Thus, each series of tests for each company lasted four weeks. The total number of car-weeks was about 250 for the summer series. The following winter this entire program was repeated under cold-weather conditions, the group of companies not being quite the same for the two series.

When the results of all these four independent series of tests had been collected, the following conclusions were reached:

(1) Within the range covered by the test fuels, the number of ton-miles per gallon is independent of the fuel volatility. Consequently, the heaviest fuel was the most economical. (Federal specifications for motor gasoline were modified on the strength of this result.)

(2) Gasoline consumption is somewhat greater in winter than in summer.

(3) Dilution of crankcase oil is consistently greater the heavier or less volatile the fuel is.

(4) Dilution of crankcase oil is much greater in cold weather than in warm weather.

(5) Small apparent differences in initial fuel-volatility have a large effect on engine starting.

(6) Starting ability is the quality most readily noted by the driver.

From this survey it was concluded that economy dictates the use of as heavy a fuel as possible but that a practical limit in this direction is set by the dilution of crankcase oil and the difficulty of starting.

Conclusions from Oil-Dilution Research

The committee then decided to make a study of crankcase-oil dilution. Data were already at hand from the analysis of samples secured in the tests mentioned. A carefully arranged program on this subject, covering nearly two years of work at the Bureau of Standards, led to the following general conclusions:

(1) Dilution depends upon the temperature of the engine cylinder-walls and upon the volatility of the gasoline, the 90-per cent point on the A.S.T.M. distillation curve being taken as an index of volatility.

(2) Dilution increases with richness of mixture.

(3) Dilution decreases with higher temperature in the crankcase, particularly when the crankcase is ventilated.

(4) Dilution is not much affected by air temperature, piston and piston-ring fit, or oil viscosity.

Thus, to reduce dilution:

(1) Operate with high cylinder-wall temperature;

(2) Reduce the time required to reach normal operating temperature;

(3) Always use as lean mixtures as practicable;

(4) Operate with high oil-temperature;

(5) Ventilate the crankcase.

As the Bureau's work on fuel consumption was supplemented by the road service-tests mentioned, the laboratory results on dilution were likewise supplemented by the analysis of some 600 samples of used crankcase-oils. These samples were collected according to a carefully prepared schedule from typical makes of car distributed throughout the Country. The collection of samples was undertaken by the Research Department of the Society, and the results have been summarized and published in THE JOURNAL, where other papers will be found covering the results herein outlined.

Results of Engine-Starting Studies

The results mentioned indicated that the volatility of the gasoline in the initial portion of the distillation range, in its effect on starting, was the characteristic most readily recognized by the user. This led to undertaking the third major portion of the program; namely, the effect of initial volatility on engine starting. To make this research of tangible value, it was necessary first to devise a method of measuring the volatility of the fuel which would give results comparable with those obtained in the engine manifold. Such a method was devised and after a series of careful comparisons it was found that the same result could be obtained from the standard A.S.T.M. distillation test. It was found possible to correlate the results of distillation tests with those of a long series of engine-starting tests performed in the laboratory and to arrive at very useful conclusions which are only beginning to find general application. The result may be stated somewhat as follows:

Given a fuel of which the distillation data are known

and an engine the choke mechanism of which will deliver a 1-to-1 fuel-air mixture or any other known mixture ratio, one can state the minimum temperature at which that engine-fuel combination will start with about 10 revolutions of the crankshaft; also the minimum temperature at which the engine can be started at all.

This result makes it possible for the first time to select or specify a fuel which will give proper starting under any specified condition. This information should go far toward securing uniform starting conditions through better control of engine-starting devices, and of fuel volatility in relation to temperature.

Another phase of this project dealing with the effect of fuel volatility has to do with the effect of this property on acceleration and general behavior of the engine. The relationship between the form of the distillation curve and performance of the engine when cold are not so readily summarized as are the items already mentioned. In general, nearly the maximum acceleration of which an engine is capable can be obtained with almost any fuel, but a much richer mixture is required if the fuel is less volatile. Practically, therefore, it is more difficult to secure quick pick-up, which means maximum engine acceleration, with the heavier or less volatile fuel simply because it is more difficult to control the mixture ratio.

Another portion of this project was undertaken to determine whether the intermediate range of volatility, as represented by the 50-per cent distillation point, has a significant influence on engine acceleration. A study of this point has shown that, while there is some influence of this sort, the effects noted are somewhat erratic and seem to depend upon accidental rather than essential features of design and operation. In view of this result, a program is now under way for the analysis of the performance of a number of typical engine designs. For this purpose some of the staff of the Bureau will make observations with the Bureau of Standards equipment in the laboratories of several of the automobile factories. The details of this program are described in the paper by Donald Brooks on Design-Factor Engine-Acceleration Tests.

Studying Knock Characteristics of Fuel

The latest of the cooperative-fuel-research projects and the one now occupying most of the time of the Bureau staff is that of deciding upon satisfactory apparatus and technique for the measurement of the knock characteristics of fuel. This project is now in active progress. Final results are not to be expected for some months. The special test engine exhibited at the Annual Meeting of the Society in January, 1929, is now being set up in the various laboratories represented on the detonation subcommittee and a program of preliminary tests, designed to reveal any faults in the engine and to indicate the most promising lines for further work, has been agreed upon. On the basis of this work the steering committee probably will invite a larger group of laboratories to join in cooperative tests, with the object of arriving at a tentative standard method of knock-testing.

In conclusion, I desire to emphasize that the fuel-research project, on which the two industries have spent about $4,500 per year each, has brought the engineering staffs of the two industries into accord; has contributed largely to fuel saving for the Country; has afforded all the technical data needed to combat crankcase dilution, which data has been well utilized; has afforded complete data on the relationship of fuels to engine starting, which have not yet been fully utilized; has cleared up the question of the effect of fuel on engine acceleration; and is now concerned with securing a satisfactory technical control over the relationship between fuels and engine compression-ratios.

APPENDIX

Cooperative Fuel Research Publications

All the cooperative-fuel-research progress reports which have been presented at previous general meetings of the Society or the American Petroleum Institute are listed below, together with certain papers on the same or related subjects which have been presented at meetings of the American Chemical Society.

Journal of the Society of Automotive Engineers

Economic Motor-Fuel Volatility; February, 1923, p. 137
Economic Motor-Fuel Volatility; July, 1923, p. 3
Economic Motor-Fuel Volatility; March, 1924, p. 267
Factors Affecting the Rate of Crankcase-Oil Dilution; July, 1924, p. 69
Transition Method for Measuring Crankcase-Oil Dilution; October, 1924, p. 334
Recent Cooperative Fuel Research Progress; February, 1925, p. 237
Measuring the Percentage of Crankcase-Oil Dilution; March, 1925, p. 355
Engine-Starting Tests; July, 1925, p. 52
Progress Report on Engine-Starting Tests; February, 1926, p. 147
Cooperative Fuel Research (general summary); April, 1926, p. 349
Progress in Measurement of Motor-Fuel Volatility; April, 1926, p. 393
Additional Engine-Starting Tests; July, 1926, p. 3
Volatility Tests for Automobile Fuels; August, 1926, p. 151
Fuel Research Summarized; February, 1927, p. 193
Fuel Requirements for Engine-Starting; March, 1927, p. 353
Methods of Measuring the Antiknock Value of Fuels; May, 1927, p. 599
Starting Ability of Fuels Compared (lean explosive limits for cracked and straight-run gasolines and other motor fuels); July, 1927, p. 15
Engine-Acceleration Tests; August, 1927, p. 184
Volatility Data from Gasoline Distillation Curves; April, 1928, p. 437
Results of Two Recent Detonation Surveys; April, 1928, p. 448
Influence of Fuel Characteristics on Engine Acceleration; September, 1928, p. 235
Dew-Point Data on Gasoline; November, 1928, p. 478
Vapor-Pressure Data on Motor Gasolines; May, 1929, p. 488
Economic Fuel Volatility and Engine Acceleration; July, 1929, p. 669
Operating Factors in Engine Acceleration; printed in this number, p. 130.

Bulletin of the American Petroleum Institute

Results Obtained from Joint Research Tests; Dec. 30, 1922, p. 95
Economic Motor-Fuel Volatility; Dec. 31, 1923, p. 121
Economic Motor-Fuel Volatility; Dec. 31, 1924, p. 115
Measurement of Crankcase Dilution; Dec. 31, 1924, p. 122
Effects of Fuel and Engine Design on Starting; April 12, 1926, p. 121
The Cooperative Fuel Research at U. S. Bureau of Standards—1922-1925; Jan. 31, 1927, p. 141
Fuel Characteristics and Engine Starting; Jan. 31, 1927, p. 143

An Interpretation of the A.S.T.M. Distillation Curves of Motor Fuels; Jan. 31, 1928, p. 54
The Lean Explosive Limits of Cracked and Straight-Run Gasolines; Jan. 31, 1928, p. 69
Some Factors in Engine Acceleration; Jan. 31, 1928, p. 74
A Detonation Survey; Jan. 31, 1928, p. 81
Equilibrium Volatility of Motor Fuels; Jan. 3, 1929, sect. II, p. 124
Relation of Fuel to Engine Acceleration; Jan. 3, 1929, sect. II, p. 143

Industrial and Engineering Chemistry

Fuel Requirements of Internal-Combustion Engines; May, 1923, p. 476
Lubrication Data from Cooperative Fuel Research; May, 1926, p. 482
Dew-Points of Air-Gasoline Mixtures from Distillation Curves; August, 1928, p. 821
Auto-Ignition Temperatures of Liquid Fuels; November, 1928, p. 1219
Vapor Pressure of Hydrocarbons; not yet published.

Program for Determination of Effect of Engine Design on Acceleration[1]

By DONALD B. BROOKS[2]

SEMI-ANNUAL MEETING PAPER *Illustrated with* PHOTOGRAPHS AND A DRAWING

SO FAR, all Cooperative Fuel Research acceleration tests have been made on one engine. Hence, to make these results generally applicable, it is necessary to know the effect of engine design on the various factors influencing acceleration. For this purpose, a portable model of the previously described spark accelerometer has been designed. With this apparatus, identical series of acceleration tests will be made on about ten representative automobile engines at the manufacturers' laboratories.

IN a paper[3] presented at the last Annual Meeting, a qualitative correlation was shown between the A.S.T.M. distillation curves of three special fuels and their effectiveness for acceleration. Since that time further tests on three other fuels have also shown this relation. Tests made by Prof. G. G. Brown[4] indicate a similar qualitative correlation with other fuels and a different engine. However, as Professor Brown's engine and that used at the Bureau of Standards are of similar design, further tests on other engines are necessary to determine whether the correlation is at all general.

To make these and other results thus far obtained in the acceleration research at the Bureau of Standards more generally applicable, the Cooperative Fuel Research Steering Committee, at its meeting on Feb. 11, 1929, authorized a program of design-factor engine-acceleration tests. The Committee further decided that these tests should cover about ten engines, representative of modern design, and be conducted at the laboratories of automobile companies desiring to cooperate in this work.

Apparatus Built for the Work

The earlier accelerometer, it will be recalled, consists essentially of a sprocket driven by the engine, which draws perforated paper tape between a pair of electrodes. Across these electrodes a regularly-timed spark is discharged. The result is a series of holes in the tape, spaced proportional to the engine speed. From these speed records, acceleration is obtained by graphical or numerical computation.

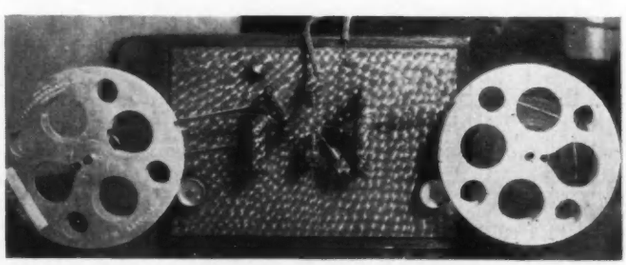


FIG. 1—FRONT VIEW OF PORTABLE SPARK-ACCELEROMETER DESIGNED AND BUILT FOR MAKING DESIGN-FACTOR ENGINE-ACCELERATION TESTS, SHOWING TAPE-WINDING REELS

For this work it has been necessary to construct a portable model spark-accelerometer. This instrument was designed on the basis of the old spark-accelerometer, with the following requirements in mind: It must be easily portable, sufficiently precise for the work, capable of being operated entirely on 6-volt storage batteries, capable of being set up or changed from one engine to another with the minimum effort and time loss, and as automatic and simple to operate as possible.

Although several minor changes have been made in designing this new model accelerometer, only one radical departure has been made; a flexible-type drive has been incorporated to avoid the necessity for precise alignment. This drive is similar to that used on tachometers and makes driving through a right angle possible. As the cable is $\frac{5}{8}$ in. in diameter, it has satisfactorily high torsional rigidity.

[1] Approved for publication by the Director of the Bureau of Standards, City of Washington.

[2] S.M.S.A.E.—Associate engineer, Bureau of Standards, City of Washington.

[3] See S.A.E. JOURNAL, June, 1929, pp. 609 to 616.

[4] From a private communication.

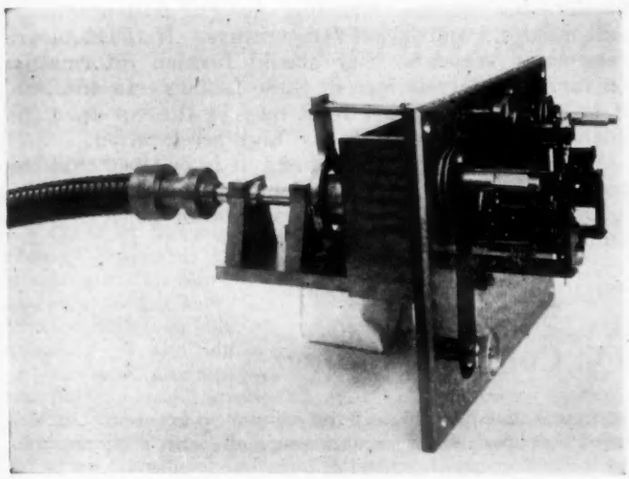


FIG. 2—QUARTER VIEW OF ACCELEROMETER WITH CASING REMOVED TO SHOW SELF-ADJUSTING CLUTCH AND FLEXIBLE DRIVE

In addition, the new accelerometer, shown in Fig. 1, has a take-up reel, driven by a spring-belt, for automatically winding up used tape. The bronze bearings on the main and idle-sprocket shafts are all adjustable for wear.

The self-adjusting clutch is mounted integral with the accelerometer, as can be seen in Fig. 2, which also shows the flexible drive connected to the accelerometer. Other details are essentially identical with the first model, described in an earlier paper[5] of this series.

The tuning-fork (Fig. 3) was built to the specifications of the Bureau of Standards. It is a six-cycle fork, operating on 5.5 to 7 volts, and drawing a mean current of 0.29 amp. It has positive-break contacts[6] similar to the fork used in previous work here. Fig. 4 shows the apparatus assembled for use, and Fig. 5 is a diagram of the electrical connections.

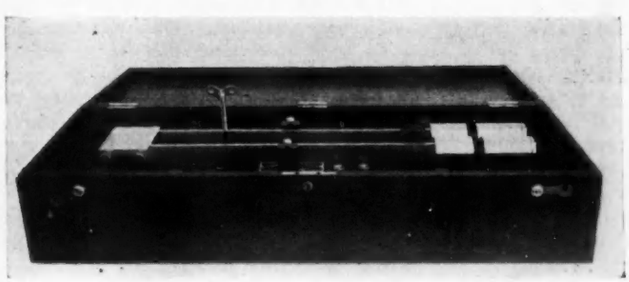


FIG. 3—SIX-CYCLE TUNING FORK PROVIDED WITH POSITIVE-BREAK CONTACTS AND OPERATING ON 5.5 TO 7 VOLTS

To install this apparatus it is necessary merely to connect the flexible drive to the engine by means of a suitable adapter, connect one battery to the ignition coil and another to the tuning-fork, and make the necessary electrical connections between the separate parts of the apparatus. This can be done in less time than is required to thoroughly warm up an engine.

Only one accessory, the disc whose inertia represents that of the automobile, has not been included in the apparatus as designed. Since a different inertia is required for each engine, the making of a separate disc for each engine tested is believed to be more satisfactory.

Test Programs and Conditions

The contemplated program requires identical tests on each of ten typical engines, under conditions as follows:

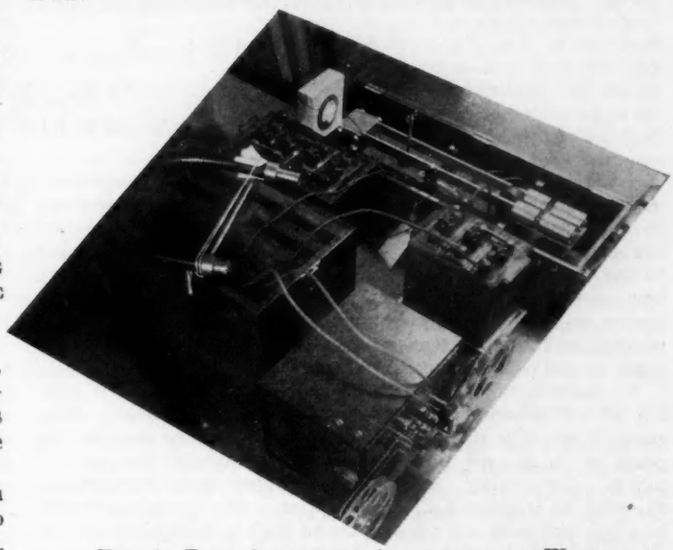


FIG. 4—TEST APPARATUS ASSEMBLED FOR WORK

(1) *Carbureter and Engine Performance.*—Runs under comparative test-conditions, with and without an accelerating-charge device on the carbureter

(2) *Manifold Performance.*—Runs with the engines firing separately various combinations of cylinders[7]

(3) *Effect of Fuel Volatility.*—Runs at each of three manifold and jacket temperatures with each of three special fuels with the carbureter set for a leaner mixture than that for maximum ac-

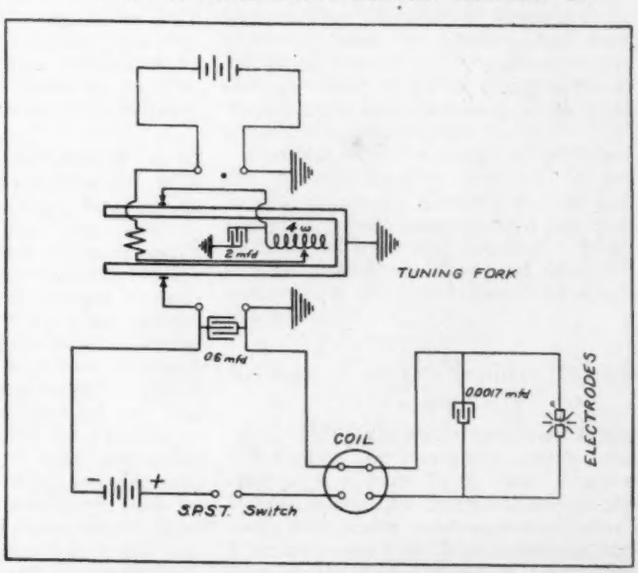


FIG. 5—WIRING DIAGRAM SHOWING ELECTRICAL CONNECTIONS FOR INSTALLING THE APPARATUS

[5] See the S.A.E. JOURNAL, September, 1928, p. 235.

[6] See *Journal of Scientific Instruments* (London), March, 1924, p. 161.

[7] See Operating Factors and Engine Acceleration, by Donald B. Brooks, p. 130 in this issue of the S.A.E. JOURNAL.

celeration. The fuels used will have nearly the same A.S.T.M. 10-per cent points but will differ widely above that point

(4) *Engine Power.*—Runs on the dynamometer to determine the engine maximum-torque characteristic over the speed range covered in the acceleration tests.

This program will provide data that will render possible the evaluation of the influence of engine design on the effect upon acceleration of the following factors: accelerating charge, manifold design, fuel volatility, and manifold and jacket temperature. If the data are reasonably accurate, they should furnish information on various interrelations of these factors. In addition, it is hoped that further light may be thrown upon the phenomenon known as "initial high acceleration."

With this information at hand, it is believed that the acceleration data previously obtained during the Co-operative Fuel Research work will be of general applicability.

Piston Leakage and Oil Consumption

IN THE STUDY of piston-ring performance, dynamometer tests are made with runs at engine speeds corresponding to car speeds of 20, 25 and 30 m.p.h., and so on to the highest speed of the car. The load for each run is adjusted to the estimated load on a normal road at the corresponding speed. Oil consumption and leakage of gas past the piston are the most important observations taken in tests of this sort, and curves plotted from the results of such tests reveal some very interesting conditions.

An examination of the curve representing miles per gallon of oil consumed shows the following tendencies: The curve is slightly rising at 20 m.p.h. and usually reaches its peak of maximum miles per gallon between 30 and 35 m.p.h. Continuing, there is a decided turn downward, showing an increased oil consumption. The curve continues to drop, but it is not uncommon to find it flattening out at 50 m.p.h. and showing a smaller increase in oil consumption between 55 and 60 m.p.h. than between 45 and 50 m.p.h. This, like many other peculiarities, seems to have no well-founded explanation.

At 20 m.p.h. the effect of speed on oil consumption is negligible, but the effect of the vacuum is greatest. As the speed is increased the vacuum drops off, with a corresponding reduction in oil consumption. This continues up to 30 or 35 m.p.h., at which point the effect of speed becomes more acute and dominates the remainder of the curve.

Analysis of the blow-by curve shows a continual rise, indicating a similar increase in the blow-by from a speed corresponding to 20 m.p.h. up to the maximum speed of the test. This curve usually is comparatively flat between 20 and 35 m.p.h. Beyond this point it is not always consistent, but usually shows a more rapid rise as the speed is increased. A thorough study of the problem of piston-ring leakage shows that the power loss due directly to the volume of gas lost is not so serious as the effect of the blow-by on the life of the pistons and rings. Frequently, pistons that normally would run perfectly free, expand and score because of excessive blow-by. Even if the amount of blow-by is not sufficient to cause scoring, it may be enough to burn or blow away the lubricant and materially shorten the life of the parts.—From a paper by Ralph R. Teetor, delivered at an Indiana Section meeting.

Aeronautic Engineering

Ignition-Shielding Conference

Magneto Outlets, Ignition Cable, Spark-Plug Shielding and Test Methods Discussed

AT the conference called at the Bureau of Standards in Washington on June 11 to discuss the problems relating to the shielding of ignition on airplane engines, the Society was represented by P. B. Taylor, acting chief powerplant engineer of the Wright Aeronautical Corp. Although the official record of the meeting was not available at the time of preparing this account, Mr. Taylor's report to the Society indicated that the conference was attended by about 60 representatives of the Army, Navy, Bureau of Standards and manufacturers of engines and ignition equipment.

After a brief description of the work being done at the Bureau of Standards was given, discussion turned to the various factors involved in the problem and to statements by those present of their studies of shielding as related to the several parts of ignition apparatus. Regarding ignition wiring, the assertion was made that broken braid over the wire ruptures or mars the lacquer film on the braid and causes corona, but that the dielectric stress in the cable is not sufficient to cause breakdown. A statement was also made that the added capacity of the braid has no effect on ignition, but that cross-firing may result when several wires are run through the same tube, the remedy for which is to run only one wire in a tube. Evident trouble from short bends in ignition cable led to the suggestion that bends of less than ⅜-in. radius should be avoided and that 9-mm.-diameter wire should be made the standard, but the opinion was also expressed that the present standard of 7 mm. should be retained.

Several methods of shielding spark-plugs, including molded and sheet-metal types, were exhibited and the result of tests on them discussed, one point cited being the loss of engine speed when operating in the rain with shielding of the present types.

An interesting description was given of a method of using flexible metal hose having a braid on the outside. In this connection the possibility of using metal plating over solid rubber was mentioned. A representative from the Army stated that it is not necessary to waterproof above the wire insulation if the spark-plugs and magnetos are water-proof.

The question of a standard outlet for magnetos was discussed at the afternoon session and resulted in a vote of 16 to 3 in favor of the adoption of a tentative standard for a top outlet substantially the same as a sample shown, one reason for the suggested standard being to enable the engine manufacturers to reduce the number of designs now being used. Another exhibit was a completely shielded magneto having two outlets on the top.

In a general discussion of shielding, a representative of the Signal Corps stated that little or no additional shielding is necessary when the type of cowling developed by the National Advisory Committee for Aeronautics is used, citing the cases of air-cooled Liberty engines. The representative of the Radio Frequency Laboratory explained a method that has been devised for locating leakage in the electrical apparatus and indicated that some interference is caused by leakage around the magneto driveshaft. He also expressed the opinion that, for completely effective shielding, it is necessary to reduce the noise resulting from ignition to 1/1000 of its initial value.

A number of tests for the finished shielding were discussed prior to concluding the conference, and several definite recommendations were approved.

Committee to Make Research

Plans are now progressing for organizing an Aeronautical Research Committee in the Research Department of the Society, and electrical shielding probably will be one of the first subjects taken up by that Committee.

Aircraft Standards Session

Lighting Requirements To Be Discussed at Standards Session at Cleveland Aeronautic Meeting

AERONAUTIC standardization will be given first attention at the S.A.E. Aeronautic Meeting to be held Aug. 26 to 28 in cooperation with the Aeronautical Chamber of Commerce in Cleveland during the week of the National Air Races and Aircraft Exposition.

The program of the Society is to open at 10 a.m. Monday, Aug. 26, with an Aeronautic Standards Session, at which the Aircraft Lighting Committee, which is carrying on a research into aircraft lighting requirements for landing purposes, will present a summary of the work accomplished to date and a layout of the installation to be made in the various airplanes on which the test will be run. A complete set of the equipment to be installed on these planes will be exhibited for the inspection and criticism of those attending the session, if present plans eventuate.

All airway operators have been invited to have their representatives present at this session, and it is hoped that the work of the Aircraft Lighting Committee will be furthered and benefited by the discussion.

R. B. C. Noorduyn, Chairman of the Standards Committee appointed by the Aeronautical Chamber of Commerce to cooperate with the Society, has been invited to present at the standards session any new views or suggestions of the airplane manufacturers as to their standards requirements.

Members of the Aircraft Division and the Aircraft-Engine Division of the S.A.E. Standards Committee are also expected to be present so that any suggestions offered and discussion given will be considered later and used for guidance in the development of specifications.

Airway Weather-Reports Broadcast

AN INTENSIVE weather-reporting service for aviators which was started on July 1 by the Weather Bureau along the transcontinental airways broadcasts weather reports every 3 hr. by voice from four collecting centers of the Department of Commerce. These stations, located at Cleveland, Omaha, Salt Lake City and San Fran-

cisco, receive telegraphic reports every 3 hr., day and night, from about 60 selected reporting stations situated on both sides of the airways and about 100 to 200 miles from the route taken by fliers. These reports are entered on small-area maps supplementing the country-wide morning and evening weather maps, and are used as the basis for summarized statements of current and predicted conditions. A wave-length of about 900 meters (315 to 350 kilocycles) is used for broadcasting them. A strip approximately 400 miles wide stretching from coast to coast is covered by this network of stations, which are about 60 miles apart.

Commercial airline aircraft are now equipped with radio receiving sets for picking up the information along the route. The reports can also be picked up by persons on the ground having suitable receiving sets. They give the general character of the weather, the ceiling or prevailing cloud-type, the visibility, wind direction and velocity, temperature, dew-point in some cases, pressure, and any unusual conditions. When storms or other hazardous conditions are noted approaching the airway at right angles, they will be reported, whereas mention of them might not have been made in an earlier report at the time of taking off of an airplane.

This 3-hr. information service should be of special use to airport managers, air-transport officials and many in other lines of business within 150 or 200 miles of the broadcasting stations. Eventually, the system may be extended to include the three great transverse airways extending from the northern to the southern boundaries of the United States.

Airway-Marking Report

Uniform System of Pointers Based on Tests for Use on Building Roofs Recommended

CONCRETE recommendations for uniform airway-markings, designed to guide pilots on their flights between airports, were made by the Airway Marking Committee of the Aeronautics Branch, Department of Commerce, in the report submitted Jan. 23. This Committee was appointed following the Airways Marking Conference held at Wichita, Kan., May 10 and 11, and has not only make a study of various suggestions aimed at suitable markings but undertaken practical day and night tests to determine the most satisfactory markings for use on building roofs.

After concluding these tests on Jan. 5, the Committee reported that, in its opinion, the general use of a standard system of air-marking that will convey the necessary information to the pilots in the simplest and most effective way is one of the most immediately needed aids to air navigation at present, and that every city, town, and hamlet should be adequately air-marked.

Markings should be as simple as possible consistent with the information to be conveyed; of size and color ensuring maximum attractive power and visibility under all flight conditions; easily legible from average altitude and so illuminated as to be as effective by night as by day. They should be permanent, economical to construct and maintain, and placed in accordance with a fairly definite system so that pilots may know where to expect them.

It is important that the markings give the pilot his position and enable him to orient himself; also that they indicate the direction and distance to the nearest landing-field, the size of the field and the general equipment and facilities available, including facilities for night operation. Hence, the Committee recommended that, when possible, they include the name of the city or locality, a meridian marker, and, if there is an airport in the vicinity, a combination of simple characters indicating the direction and distance to the airport, the rating of the port, and whether facilities are available for landplanes, seaplanes, or both.

It is not believed to be necessary that route markings other than those provided in connection with the Federal airway system be used.

Size and Style of Lettering

The effective reading distance of air-markings depends upon the size and shape of the letters or characters used, their spacing and the degree of contrast between the characters and the background. Tests made indicate that chrome-yellow characters on a dead-black background give the best results, hence this color combination is recommended for standard use in all air-marking.

The height of lettering used for the name of the city or town should be from 10 to 30 ft., as available space may permit. Under no circumstances, however, should the lettering be less than 6 ft. in height. It is recommended that plain vertical gothic capital lettering be used in all air-marking, with the spacing between the letters not less than one-fourth of the letter height.

It is recommended, for the meridian marker shown in Fig. 1 (*j*), that the letter N should be from 6 to 12 ft. in height as space may permit, overall length of the marker being from six to seven times the height of this letter.

Combinations of characters recommended for standard use for airport and landing-field pointers are shown in Fig. 1 (*a*) to (*i*), inclusive. Fig. 1 (*a*) gives in detail the proportions recommended for this symbol. Suitable lettering within the circle gives the rating of the airport, or, if unrated, the class of the airport or landing-field. In seaplane airports the letter S precedes the circle (*b*), and in landplane airports offering seaplane facilities, letters LS precede the circle (*c*),

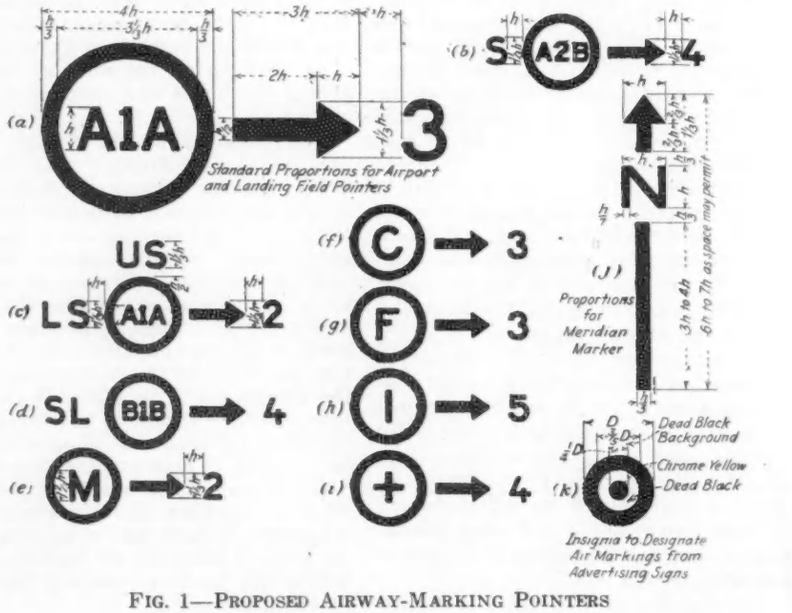


FIG. 1—PROPOSED AIRWAY-MARKING POINTERS

the rating within the circle being that of the landplane airport. Letters US above the circle indicate airports designated by the Federal Government as airports of entry of the United States. Pointers indicating seaplane airports with facilities for landplanes should have the letters SL preceding the circle (*d*), the rating within the circle being that of the seaplane port. Airport pointers used to indicate unrated municipal airports, unrated commercial airports, Federal airdromes or air stations, Department of Commerce intermediate landing-fields, or marked auxiliary fields, should use the letters M, C, F, I, or a Greek cross as shown in (*e*) to (*i*), respectively.

Personnel of Markings Committee

The list of Committee members and of the agencies or organizations represented by them follows:

Harry H. Blee (chairman), chief of airport section, Aeronautics Branch, Department of Commerce, representing the Aeronautics Branch of the Department of Commerce

Lieut. A. P. Flagg, officer in charge of training, Bureau of Aeronautics, Navy Department, representing the Bureau of Aeronautics of the Navy Department

Woody Hockaday, of Wichita, Kan., representing the National Airway Marking Association

Capt. Harold M. McClelland, chief of operations section, office of Chief of Air Corps, War Department, representing the Army Air Corps

C. I. Stanton, airways engineer, airways division, Bureau of Lighthouses, Department of Commerce, representing the airways division of the Bureau of Lighthouses

John Groves, in charge of airway bulletins, Aeronautics Branch, Department of Commerce (secretary of the Committee).

Changes Made in Aircraft Engineering Code

THIRTY-EIGHT specific changes in the airworthiness requirements of the Department of Commerce aircraft engineering code are intended mainly to add to the safety and comfort of airplanes produced in the United States. As the printing of the revised code by the Government Printing Office is expected to be delayed until early next year, the Aeronautical Chamber of Commerce has prepared advance copies for distribution among airplane manufacturers.

Among the new requirements are the following:

Strength tests of all control surfaces and systems

Tests of the shock-absorbing qualities of landing-gears on the airplane

Tests to destruction of samples of all wooden members, and physical-property tests of all samples that fail

Cabins must have one exit for every six persons carried. Detailed specifications for all exits and openings are given

Requirements for the installation of engines have been expanded to include detailed instructions

Clearance of the propeller above ground on landplanes has been increased to a minimum of 9 in., and a clearance of 18 in. is specified for seaplanes

Propellers are required to be designed and adjusted to limit the engine speed at full throttle in level flight to 105 per cent of the official rated speed. Performance and flight-test specifications have been amplified so that they describe the procedure of Department of Commerce inspectors. New propellers will no longer be accepted by the Department upon an affidavit of 150 hr. of service flight

The relative efficiency of biplane wings must be determined from rational formulas instead of the curves formerly specified

Methods for calculating air load and dead weight for wings tapered in thickness ratio have been changed to comply with the latest facts known to aeronautic engineers

A paragraph relating to the construction of gliders has been added to the airworthiness requirements.

A.A.A. Air-Travel Division

AN AIR-TRAVEL division has been formed by the American Automobile Association to supply information to persons desiring to travel by air. After making a comprehensive survey of the field of aviation from the standpoint of services that might be rendered by the affiliated automobile clubs, the National headquarters of the A. A. A. prepared a program which has been endorsed by the Department of Commerce. The service which many of the clubs are now prepared to furnish includes information regarding:

Regulations, including licensing, operation and ownership of aircraft, licensing of pilots and mechanics, marking of licensed and unlicensed aircraft, inspection of aircraft, and air-travel regulations

Aviation weather forecasts

Aviation maps

Schedules and tariffs for air transport, including passengers, express and mail

Accredited schools for aviation training

Airports and landing-fields

In addition to the foregoing, it is anticipated that the A. A. A. clubs will take an active part in promoting aviation by assisting in the securing and improvement of airports in their respective communities, by rendering emergency service to aviators, and in various other ways.

Airdrome Police at Tempelhof

ALL AIRPORT buildings and equipment at Tempelhof airport, as well as at Croydon and Le Bourget, have been constructed and arranged with safe operation and effective control as the dominating factor.

At Tempelhof the activities consist largely of the scheduled operations of the Luft Hansa and one or two other organizations. Local flying is maintained to some extent during favorable seasons, but, as in the case of Le Bourget and Croydon, it does not constitute a dominating factor. Apparently, no flying instruction of any kind is carried on at the airdrome.

All departing aircraft must taxi from the loading platform after receiving a signal from the police traffic-officer stationed on the control tower. The aircraft then proceeds to the take-off point, which is indicated by another traffic-officer standing at the proper location. The actual take-off run is not started until a signal is given by the latter officer. This rule applies whether the aircraft is on scheduled service or engaged in an unscheduled flight of some kind. All aircraft must have an announced destination and be properly cleared for it.

Arriving aircraft are required to taxi to the same platform for the purpose of reporting in and discharging any passengers or cargo. Such aircraft, when landing after dark, must receive a signal from the control tower in the form of a green Very light or its equivalent. A red signal, given in similar way, means to remain aloft until a subsequent landing signal is given.

More than usual control is exercised over the air traffic at Tempelhof and every effort is directed toward the safe operation of the airdrome. The "airdrome police" introduces a feature which, while common to the various airdromes in Germany, does not prevail elsewhere in Europe.

The entire system of aircraft operation is designed to leave no question in the mind of the pilot; therefore, there is no confusion, and a consequent elimination of unusual and unnecessary hazard. Obviously, such a condition is extremely desirable and beneficial.—Major Clarence M. Young.

Civil Aeronautics Progress

A RECENT canvass by the Division of Airports and Aeronautic Information of the Department of Commerce shows 4346 planes of all types produced in the United States in 1928, with a value at the plant of nearly $44,000,000. Aircraft engines manufactured during this period numbered 3496, valued at $20,000,000.

The third anniversary of the establishment of the Aeronautics Branch of the Department, July 1, 1929, found the Country with approximately 10,000 miles of airways lighted for night flying. Airplanes operating on scheduled transport-service flew 10,500,000 miles during the year, and planes engaged in miscellaneous, commercial, and private flying covered some 60,000,000 miles. In the regular air-transport service, 45 operating companies are now flying 70,000 miles per day, carrying mail, express, and passengers. About 25,000 miles of this daily scheduled operation are being flown during the night.

Standardization Activities

Straight-Shank Drill Sizes

Industries Asked To Indicate Choice of Proposals for Adoption as American Standard

AS STANDARDIZATION of twist-drill sizes and lengths is a project of great importance to virtually all mechanical industries, the following proposals are submitted at this time to give manufacturers using drills an opportunity to indicate to the Committee that prepared the proposals which of the two should be selected for adoption as the American Standard.

This work was started about a year ago by the Sectional Committee on the Standardization of Small Tools and Machine-Tool Elements that is sponsored by the S.A.E., the American Society of Mechanical Engineers and the National Machine Tool Builders Association under the procedure of the American Standards Association. A Technical Committee No. 7 was organized to make a survey of drill sizes and lengths now in common use and to draft a proposal for standard. The Technical Committee has found that at present the drill manufacturers and users catalog and carry in stock about 138 drill sizes, ranging from No. 80 (0.0135 in.) to ½ in., inclusive, and that much discrepancy exists in jobbers' lengths of straight-shank drills, as is shown by the irregularities in drill lengths for the 1/16-in. drill and larger sizes. It is proposed to modify the existing lengths in accordance with the accompanying tables and charts so as to establish a consistent progression and extend the present jobbers' series to include the 11/16-in. size.

The Committee estimates that the standardization of straight-shank drill

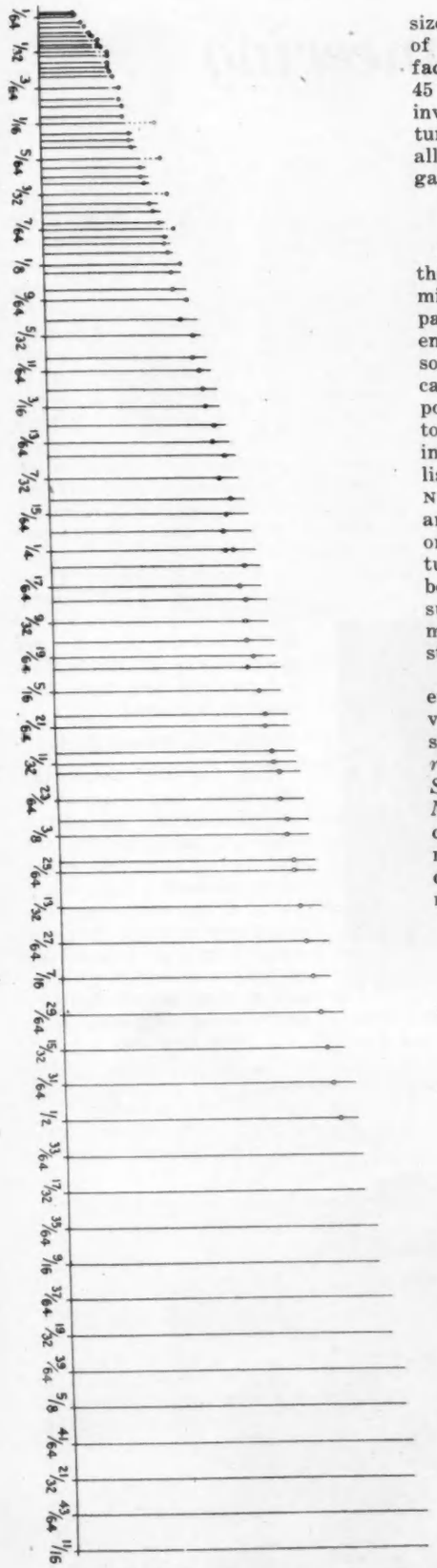
TABLE NO. 1—PROPOSAL A

Drill Size	Length		Drill Size	Length	
	Present	Proposed		Present	Proposed
0.0140	.....	1 3/16	13/64 (0.2031)	3 5/8	4
1/64 (0.0156)	.....	1 3/16	0.2110	.....	4 1/16
0.0180	1 5/16	7/8	0.2150 (a)	.....	4 3/16
0.0200	1	1 5/16	7/32 (0.2188)	3 3/4	4 5/16
0.0220	.....	1	0.2270	.....	4 5/16
0.0240	1 3/16	1 1/16	15/64 (0.2344)	3 7/8	4 5/8
0.0260	1 5/16	1 1/8	0.2420	3 13/16	4 7/16
0.0280	1 5/16	1 3/16	1/4 (0.2500)	4	4 1/2
1/32 (0.0313)	1 1/2	1 1/4	0.2580	.....	4 5/8
0.0330	1 1/2	1 5/16	17/64 (0.2656)	4 1/8	4 5/8
0.0350	1 1/2	1 3/8	0.2700 (a)	.....	4 3/4
0.0370	1 1/2	1 3/8	0.2740	.....	4 3/4
0.0390	1 1/2	1 7/16	9/32 (0.2813)	4 1/4	4 3/4
0.0410	1 9/16	1 1/2	0.2890	.....	4 7/8
0.0430	1 11/16	1 1/2	19/64 (0.2969)	4 3/8	4 7/8
3/64 (0.0469)	1 3/4	1 9/16	0.3050	.....	5
0.0510	.....	1 11/16	5/16 (0.3125)	4 1/2	5
0.0550	1 13/16	1 3/4	0.3210	.....	5 1/8
0.0590	.....	1 13/16	21/64 (0.3281)	4 5/8	5 1/8
1/16 (0.0625)	2 1/2	1 7/8	0.3320 (a)	4 3/4	5 1/4
0.0670	1 15/16	2	0.3360	.....	5 1/4
0.0710	.....	2 1/16	11/32 (0.3438)	4 3/4	5 1/4
0.0750	.....	2 1/8	0.3520	.....	5 3/8
5/64 (0.0781)	2 5/8	2 3/16	23/64 (0.3594)	4 7/8	5 3/8
0.0820	2 3/16	2 5/16	0.3670	.....	5 1/2
0.0860	2 5/16	2 5/16	3/8 (0.3750)	5	5 1/2
0.0900	.....	2 7/16	0.3870 (a)	.....	5 5/8
3/32 (0.0938)	2 3/4	2 7/16	25/64 (0.3906)	5 1/8	5 5/8
0.0980	2 3/8	2 9/16	13/32 (0.4063)	5 1/4	5 3/4
0.1020	.....	2 5/8	27/64 (0.4219)	5 3/8	5 7/8
0.1060	.....	2 11/16	7/16 (0.4375)	5 1/2	5 7/8
7/64 (0.1094)	2 7/8	2 11/16	29/64 (0.4531)	5 5/8	6 1/8
0.1130	2 11/16	2 3/4	15/32 (0.4688)	5 3/4	6 1/8
0.1170	.....	2 13/16	31/64 (0.4844)	5 7/8	6 3/8
0.1210	.....	2 7/8	1/2 (0.5000)	6	6 3/8
1/8 (0.1250)	3	2 15/16	33/64 (0.5156)	.....	6 1/2
0.1290	.....	3 1/16	17/32 (0.5313)	.....	6 1/2
0.1330	.....	3 1/8	35/64 (0.5469)	.....	6 3/4
0.1370	.....	3 3/16	9/16 (0.5625)	.....	6 3/4
9/64 (0.1406)	3 1/8	3 1/16	37/64 (0.5781)	.....	7
0.1490	.....	3 3/8	19/32 (0.5938)	.....	7
5/32 (0.1563)	3 1/4	3 7/16	39/64 (0.6094)	.....	7 1/4
0.1600 (a)	.....	3 1/2	5/8 (0.6250)	.....	7 1/4
0.1640	.....	3 9/16	41/64 (0.6406)	.....	7 3/8
11/64 (0.1719)	3 3/8	3 5/8	21/32 (0.6563)	.....	7 3/8
0.1800	3 7/16	3 3/4	43/64 (0.6719)	.....	7 5/8
3/16 (0.1875)	3 1/2	3 13/16	11/16 (0.6875)	.....	7 5/8
0.1960	3 11/16	3 15/16	.....	.....	.....

(a) Tap Drill Sizes.

GRAPHIC COMPARISON OF PRESENT AND PROPOSED DRILL LENGTHS FOR DRILL SIZES IN PROPOSAL A

—Proposed Sizes and Over-All Lengths.
°Present Over-All Lengths.



GRAPHIC COMPARISON OF PRESENT AND PROPOSED DRILL LENGTHS FOR THE DRILL SIZES IN PROPOSAL B

—Proposed Sizes and Over-All Lengths.
°Present Over-All Lengths.

sizes and lengths will reduce the variety of drills carried in stock by the manufacturers and users by approximately 45 per cent, with resultant savings in inventory, carrying charges, manufacturing costs and in the cost of various allied parts, such as drill bushings and gages.

Referendum to Decide Standard

Because of the great importance of this development, the Technical Committee has decided to submit the accompanying Proposals A and B to a referendum of the manufacturing industries so that those most concerned can indicate to the Committee which of the proposals they prefer. As it is impractical to send these proposals directly to all interested manufacturers, they are published in this issue of the S.A.E. JOURNAL to give all members of the Society an opportunity to review and comment on them. Probably no further opportunity will be afforded them to do this before the final report is drafted and submitted for adoption and the drill manufacturers prepare to put the standard into effect.

It is therefore very important that every company desiring to have a voice in the selection of this class of standard drill sizes and lengths, shall *review the proposals and notify the Standards Department of the Society in New York City, before Sept. 1*, as to its choice of the proposals submitted and make comments or suggestions it may desire to have placed before the Technical Committee.

Proposal A

In this proposal the drill sizes range from 0.0140 in. to 11/16 in. (0.6875) inclusive, with definite increments for the intermediate sizes established between fractional divisions as follows:

Increment	Size
0.002	From 0.0140 to 3/64 inclusive
0.004	Above 3/64 to 9/64 inclusive
0.008	Above 9/64 to 25/64 inclusive
0.016	Above 25/64 to 11/16 inclusive

Proposal B

The range of drill sizes in this proposal is from No. 80 (0.0135 in.) to 11/16 in. (0.6875) inclusive, and includes the most commonly used drills of the present number, letter and fractional sizes.

Attention of the members of the Society who are interested in machine-tools is again called to the importance of the proposed standardization and the need for their cooperation with the Technical Committee by expressing their views as to which of the proposals should be adopted. The adoption of either as a standard will not make it impossible to obtain drills of other sizes or lengths that may be required for special purposes; it will mean primarily that the present unnecessary variety will be reduced and the inconsistent sizes eventually eliminated from ordinary stocks carried.

The personnel of Technical Committee No. 7 is as follows:

C. J. Oxford, National Twist Drill & Tool Co., Chairman

(*Concluded on p.* 188)

TABLE NO. 2—PROPOSAL B

Drill Size	Length		Drill Size	Length	
	Present	Proposed		Present	Proposed
No. 80 (0.0135)	3/4	13/16	No. 30 (0.1285)	2 13/16	3
No. 79 (0.0145)	13/16	13/16	No. 29 (0.1360)	2 15/16	3 1/16
1/64 (0.0156)	.....	13/16	9/64 (0.1406)	3 1/8	3 3/16
No. 77 (0.0180)	15/16	7/8	No. 25 (0.1495)	3	3 3/16
No. 76 (0.0200)	1	15/16	5/32 (0.1563)	3 1/4	3 7/16
No. 74 (0.0225)	1 1/8	1	No. 19 (0.1660)	3 1/4	3 9/16
No. 73 (0.0240)	1 3/16	1 1/16	11/64 (0.1719)	3 3/8	3 5/8
No. 71 (0.0260)	1 5/16	1 1/8	No. 15 (0.1800)	3 7/16	3 3/4
No. 70 (0.0280)	1 5/16	1 3/16	3/16 (0.1875)	3 1/2	3 13/16
No. 69 (0.0292)	1 3/8	1 5/16	No. 9 (0.1960)	3 11/16	3 15/16
1/32 (0.0313)	1 1/2	1 1/4	13/64 (0.2031)	3 5/8	4
No. 66 (0.0330)	1 1/2	1 5/16	No. 4 (0.2090)	3 7/8	4 1/8
No. 64 (0.0360)	1 1/2	1 3/8	7/32 (0.2188)	3 3/4	4 3/16
No. 62 (0.0380)	1 1/2	1 7/16	No. 1 (0.2280)	4	4 5/16
No. 60 (0.0400)	1 9/16	1 7/16	15/64 (0.2344)	3 7/8	4 3/8
No. 58 (0.0420)	1 5/8	1 1/2	C (0.2420)	3 13/16	4 7/16
3/64 (0.0469)	1 3/4	1 9/16	A (0.2500)	4	4 1/2
No. 55 (0.0520)	1 3/4	1 11/16	F (0.2570)	4 1/4	4 5/8
No. 54 (0.0550)	1 13/16	1 3/4	17/64 (0.2656)	4 1/8	4 5/8
No. 53 (0.0595)	1 13/16	1 13/16	I (0.2720)	4 1/4	4 3/4
1/16 (0.0625)	2 1/2	1 7/8	9/32 (0.2813)	4 1/4	4 3/4
No. 51 (0.0670)	1 15/16	2	L (0.2900)	4 1/4	4 7/8
No. 50 (0.0700)	1 15/16	2 1/16	19/64 (0.2969)	4 3/8	4 7/8
No. 49 (0.0730)	2	2 1/8	N (0.3020)	4 1/4	5
5/64 (0.0781)	2 1/8	2 3/16	5/16 (0.3125)	4 1/2	5
No. 45 (0.0820)	2 3/16	2 5/16	P (0.3230)	4 5/8	5 1/8
No. 44 (0.0860)	2 3/16	2 3/8	21/64 (0.3281)	4 5/8	5 1/8
No. 43 (0.0890)	2 1/4	2 3/8	R (0.3390)	4 3/4	5 1/4
3/32 (0.0938)	2 3/4	2 7/16	11/32 (0.3438)	4 3/4	5 1/4
No. 40 (0.0980)	2 3/8	2 9/16	S (0.3480)	4 7/8	5 3/8
No. 38 (0.1015)	2 7/16	2 5/8	23/64 (0.3594)	4 7/8	5 5/8
No. 36 (0.1065)	2 9/16	2 11/16	U (0.3680)	5	5 1/2
7/64 (0.1094)	2 7/8	2 11/16	3/8 (0.3750)	5	5 1/2
No. 33 (0.1130)	2 11/16	2 3/4	W (0.3860)	5 1/8	5 5/8
No. 32 (0.1160)	2 11/16	2 13/16			
No. 31 (0.1200)	2 3/4	2 7/8			
1/8 (0.1250)	3	2 15/16			

NOTE.—Sizes 25/64 to 11/16 in. inclusive are the same as in Table No. 1, Proposal A.

Transportation Engineering

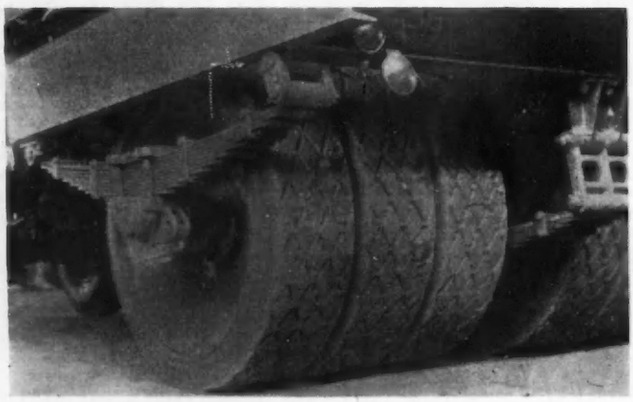
Holabird Exhibit and Pageant

Severe Tests of Varied Motor-Transport Equipment Stir Commercial Interest

AN EXHIBITION of motor-vehicles at the Holabird Quartermaster Depot, Camp Holabird, Md., June 12 to 14, consisted of motor-trucks varying from medium to heavy-duty capacity and featured largely by various types of drive to meet difficult operating conditions in Army service, such as difficult grades, loose sand, deep mud and heavy terrain.

Tests of commercial and engineering value consisted of hill-climbing ability on a 70-per cent, or 35-deg., grade, this roadway being of timbers about 8 in. wide laid ¾ to 2 in. apart. The sand road was a stretch of sandy gravel about 2 ft. deep and 50 ft. long, while the mud course was a stretch of about 400 ft. and 2 ft. deep. A series of concrete mounds and depressions, arranged to give maximum distortion of axle positions and frame weaving comprised the heavy terrain. The severity of the test was demonstrated when a four-wheel-drive truck was hauled out of the mud course by a truck equipped with caterpillar treads, which in turn had to be hauled out by a regular Army crane-truck and logging chains. The test was perilous for any but large-diameter-wheel or caterpillar-tread trucks because the muck piled up ahead of the wheels until traction disappeared.

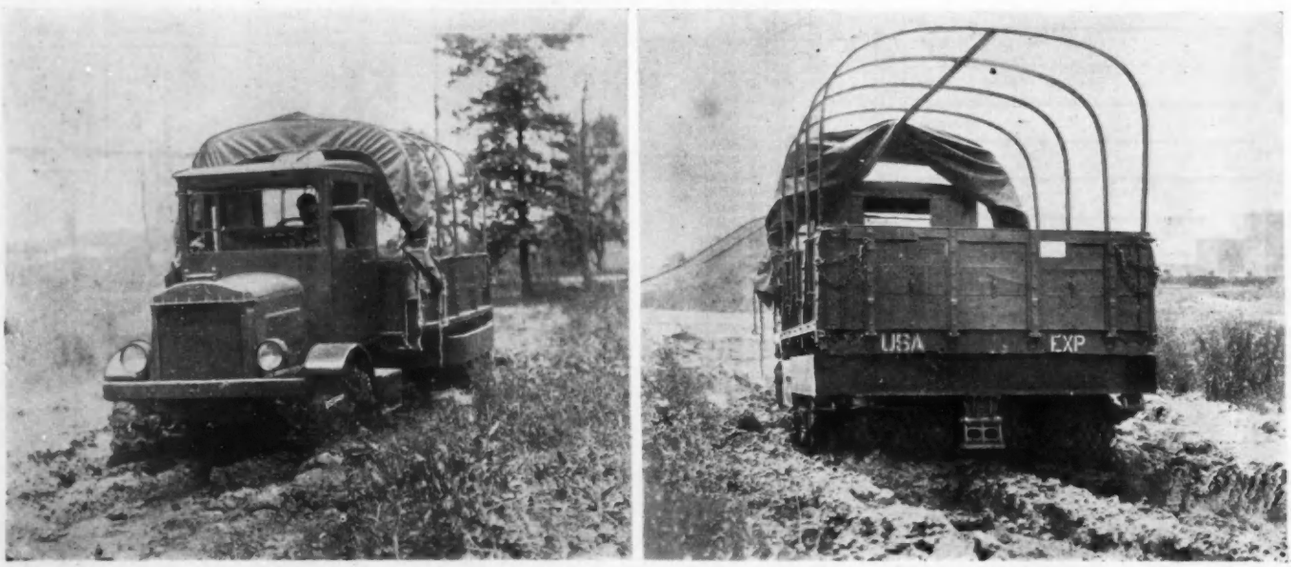
The motor-truck exhibit included 21 makes ranging from the typical four-wheel vehicle with rear-wheel drive to eight-wheel-drive trucks and from about 1-ton to 5 or 6-ton capacity. Motorcycles, engines, axles, wheels, bearings and other accessories and maintenance-depot equipment were also exhibited by 33 manufacturers. On the whole, the exhibit was an excellent showing of heavy-duty trucks and a convincing demonstration of their performance ability under the difficult conditions met with especially in military service. Daily attendance was estimated at 12,000 to 15,000 persons, many of whom represented large-scale vehicle-operators who were keenly interested in and observed closely the performance of the different vehicles and their distinctive features.



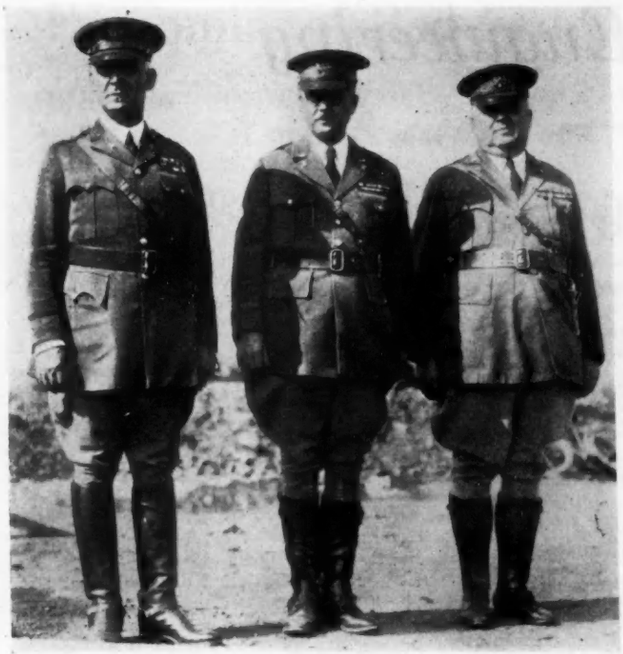
REAR AXLE AND TRIPLE TIRES OF THE ROAD-ROLLER TRUCK

The Past Comes Back

The pageant held each afternoon was instructive and interesting. It started with the announcement of visiting military and diplomatic celebrities from many parts of the world and appropriate military ceremonies. Next came processions of American Indian groups, representations of Spanish and French exploring par-



AN ARMY ROAD-ROLLER TRUCK NEGOTIATING THE MUD COURSE AT CAMP HOLABIRD



ARMY OFFICERS AT THE PAGEANT

Major Charles P. Summerall, Chief of Staff of the Army (Left); Brigadier-Gen. Francis H. Pope, Chief of Motor Transport Service, Quartermaster Corps (Center); Col. Edgar S. Stayer, Quartermaster Corps, Commanding Holabird Quartermaster Depot

ties, historic ox-carts and an original Conestoga wagon, stage coaches, General Pershing's car used during the War, a German dispatch cycle-car, and modern American military motor-transport of various types. The history of the development of rail transportation in America was portrayed by the Baltimore & Ohio Railroad with its Atlantic engine or "iron horse" and Imlay coach of 1832; the William Galloway and two freight-cars of 1857, each having a load capacity about equal to that of a small modern trailer; the William Mason of 1853; and the B. & O. modern Capitol Limited.

CONESTOGA WAGON, THE PRAIRIE SCHOONER OF THE 50's

The Holabird Quartermaster Depot

The depot at Camp Holabird was established in 1917 and comprises a tract of 161 acres on which are located the repair-shop building, 497 x 480 ft.; the motor-transport shops and machinery storehouse; supply storehouse; commissary departments; two fireproof storage buildings each 136 x 720 ft.; a crating shop 303 x 368 ft.; quarters for 600 men and 37 officers; and a station hospital.

In March, 1918, the camp was named in memory of Brigadier-Gen. S. B. Holabird, who was Quartermaster General of the United States Army from July, 1883, to June, 1900. A school was established for the training of units that were going overseas, separating the individuals according to their trade specifications and using them in the depot and convoy activities as preliminary training. Procurement of motor-transport supplies used by the War Department was made at the depot, the value of stock on hand being approximately $14,000,000.

In July, 1926, the so-called "vehicular-repair system," as applied to motor-vehicles of the Army, was terminated and the "unit-replacement system" adopted so as to reduce the cost of military motor-transport maintenance. A good detailed description of the equipment and methods used at Camp Holabird was given in the paper entitled The Army System of Maintenance of Motor Transportation, prepared by Capt. Walter C. Thee, U. S. A.,, and presented at the Society's annual Transportation Meeting at Chicago in October, 1927. This was published in the November, 1927, issue of the S.A.E. JOURNAL, beginning on p. 539.

TEST GRADE OF 70 PER CENT ON WHICH COMMERCIAL TRUCKS, CARS AND MOTORCYCLES WERE TESTED

Although much valuable engineering information has been developed by the operations at Camp Holabird, probably the available information of greatest value relates to the organization and operation of motor-vehicle-transport maintenance and the training of the personnel for that class of work. The exhibit and pageant afforded many operators and members of the Society an excellent opportunity to obtain a great deal of this useful information, both by observation and from officers of the Camp who were assigned to make such information available to those desiring it. Transportation and designing engineer members of the Society can, it is believed, secure at Camp Holabird valuable information and data that can be applied in many instances in the maintenance of commercial motor-transport equipment.

High-Strength Cast-Iron

Alloying and Patented Processes Give This Convenient Material Greatly Improved Qualities

MODERN alloy steels, first developed for purposes of war, came into common use only with the automobile industry. The same industry is chiefly responsible for a similar improvement that is now being made in cast-iron. At a meeting of the Indiana Section of the Society, held last season, representatives of three different types of improved cast-iron explained something of their processes of manufacture and usefulness.

Steel chips and scrap have been added to cast iron in the cupola for a number of years to make semi-steel, which generally is stronger than ordinary cast-iron because of the lower carbon content. Meehanite metal is produced by a process that might be described as a refinement of the ordinary method of making semi-steel, in which excess carbides are decomposed and the remaining carbides are controlled to produce a definite graphite content, in nodular form. Nodular graphite does not weaken the metal as does flake graphite, and the result is a close-grained, homogeneous material that is free from chilled edges, hard spots and porosity, and can be readily machined.

Absolute Control of Graphite

The Meehanite process consists mainly in controlling the scrap, which is melted in an ordinary cupola, and in treating the molten metal at the ladle with a cheap electric-furnace compound of calcium which controls the carbon-monoxide balance in the iron and causes deposition of graphite, without itself going into solution. The compound comes off the top of the iron in the form of dry lime. As this control is applied at the ladle, it is possible to secure varied qualities of iron from the same heat of the furnace, according to the paper which was read by Oliver Smalley, chief engineer of the Meehanite Engineering Co., who said that Meehanite can be produced at approximately the same cost as other automobile castings but that its production requires expert metallurgical supervision.

The ultimate strength and yield-point obtained from ordinary cupola Meehanite metal is said to be 46,000 lb. per sq. in., with an elongation of 5 per cent and Brinell hardness of 255. The modulus of elasticity is 27,600,000, and the resistance to corrosion under ordinary atmospheric conditions is said to be 70 per cent greater than that of cast iron. The melting range is from 1360 to 1380 deg. cent. (2480 to 2516 deg. fahr.), and high strength is retained at temperatures up to 1200 deg. fahr.

The simple process of heating to 1570 to 1600 deg. fahr. and cooling in the air increases the yield-point to 85,000 lb. per sq. in. and the ultimate strength to 90,000 lb. per sq. in., with a modulus of elasticity of 29,600,000. Quenching in oil or water makes the material glass-hard, producing a superior material for valve tappets and sleeve valves. Annealing at a temperature of 1570 to 1600 deg. fahr. gives an elongation of 4 per cent and a reduction of area of 5.4 per cent, with a Brinell hardness of 140, a modulus of elasticity of 21,200,000, and a slightly lower yield-point and ultimate strength than in the original metal. This material is referred to as semi-malleable Meehanite, and is said to have an impact strength of 3295, while that for cast iron is 61.

Alloying elements frequently are added to cast iron to improve its quality. Nickel, chromium and molybdenum are the three elements most commonly used. Other alloys contain vanadium, manganese and copper.

Nickel Helps Range of Mixture

Nickel can be added to cast iron either in the mix or at the ladle. Pig iron is available in a natural alloy containing both nickel and chromium. This is used by a large number of foundries, in quantities of say 5 per cent of the total charge. Another way of adding nickel in the mix is by the use of specially prepared blocks of nickel that have a melting-point lower than the pouring temperature of grey cast-iron. This is said to assure an even mixture. The same kind of prepared nickel is furnished also in the form of shot, that can be added to the iron at the ladle.

When nickel is added to cast iron, it is necessary to reduce the silicon content, since both silicon and nickel destroy carbides. One of the most practical and economical methods of reducing silicon is by a liberal use of steel in the base mixture.

Dwight M. Houston, foundry engineer of the International Nickel Co. and formerly in charge of the foundry of the Marmon Motor Car Co., read a paper at the same Indiana Section meeting on the subject of Super-Cast-Iron. He said that iron can be made having almost the same resistance to corrosion as brass and bronze, or that has heat-resisting or non-magnetic qualities, as well as materials having high strength. Many of the super-cast-irons are produced by patented processes.

The mixture of iron has to be changed according to the thickness of the section to be cast. It is not to be expected that the same material will be easily machinable in a thin section and perfectly dense in a heavier section, but lack of uniformity in varying sections can be greatly reduced by the introduction of alloys, which are used as a tool rather than as the backbone of the mixture.

Wear-Resistant Iron

Gunite is an iron of special quality that is particularly suitable for use in brake-drums and clutch-plates. It is similar to high-strength cast-iron except that graphic carbon is precipitated in flake form. Melting in an air-furnace is necessary to secure uniform results with this material, and no steel scrap is used in the charge. The material was described at the aforementioned meeting of the Indiana Section by D. P. Forbes, president of the Gunite Corp., who said that wear tests show that the flake graphite contained in Gunite assists considerably in reducing the wear on both the brake-drum and the brake-lining.

Another company commercially interested in the development of alloy-iron castings is the Bethlehem Steel Co., which produces a pig iron containing both nickel and chromium. Its latest product is an alloy pig containing not more than 2½ per cent total carbon, with 7 to 10 per cent silicon and 2 to 2½ per cent manganese. It is said that this high content of silicon and manganese makes it possible to use sufficient steel scrap to produce high-strength cast-iron without requiring expert control.

One of the editors of *The Iron Age* made a survey of the use of alloy-iron castings in American foundries, which was reported in the March 28, 1929, issue of that publication. This survey showed that large quantities of alloy castings, chiefly alloyed with nickel and chromium, are used for automobile-engine castings. Many of these are annealed, but few are heat-treated.

Economies of Reduced Handling

Transferring Materials Directly to Shop Floor as Received Lowers Production Costs

PROGRESSIVE production-methods in the factory are being improved continually to keep pace with increasing production-requirements and constantly lowering selling-prices. The methods in use today depend greatly on careful, systematic purchasing and the planning and scheduling of materials through the plant so that there shall be at all times a sufficient supply of materials on hand to take care of needed requirements without large banks of idle material that ties up capital needed in the conduct of the business.

Production plans originated by the administrative heads of the company are therefore usually passed first to the planning division, which makes out tentative schedules covering several months in advance. These schedules, forwarded to the purchasing department, serve as the basis on which contracts are made.

Monthly releases of these materials are originated by the scheduling department, which follows the materials from the vendors to the plant, and whose duty it is to see that the constant flow of material into the plant is uninterrupted and that the inventories of material are carefully checked and kept turning over. This department also must work in close coordination with the sales department to make any revisions in production schedules that are needed to assure the prompt shipment of finished products as completed.

Rapid Turnover Releases Capital

Careful attention to these methods should result in saving large sums of money through the rapid turning over of inventories and the elimination of excessive handling, hauling, and rehandling of materials usually incurred when large inventories are allowed to accumulate. It is not unusual to turn over inventories of all production materials as often as 25 to 30 times per year in plants in which these methods are employed, avoiding almost all obsolescence and releasing a large amount of capital for use in other channels of business. Substantial economies also result in purchasing materials.

Routing and handling of material through the factory is usually delegated to the scheduling department; and it is of the utmost importance that a steady supply of material be delivered at regular intervals to avoid interruption in machining, processing and assembling. Bulky materials especially, which would require a large amount of floor space if banked in sufficient quantities for a day's run, should be delivered by some method that will assure a steady supply without an undue amount on hand.

The materials used daily in an automobile plant may be several hundred tons or thousands of tons. The cost of handling is an important factor in manufacturing expense, and improved methods are therefore being made the subject of constant study by production executives and engineers.

Conveyors are, without doubt, the cheapest means for handling bulky materials in plants in which production is great enough to warrant their installation, and most large plants are rapidly adopting conveyors for such service. Bodies, frames, axles, wheels, engines, castings, forgings, stampings, and many other bulky parts are being transported by conveyors from one plant to another, or from freight-cars or motor-trucks, directly to the shop floor, thereby saving the cost of hauling by hand or power truck and the necessity of piling or racking them and assuring a steady flow of materials.

Economies in Inspection

Smaller and lighter materials, received in boxes, kegs or packages, can frequently be taken by either hand or power trucks directly to the shop floor in the original containers and counted and inspected as used, avoiding the expense of inspecting and sending the parts to stockrooms to be stored and rehandled before using. Materials received in bulk, such as forgings, castings, and small parts, can often be received, counted and inspected at the point of unloading. Then they can be thrown into steel boxes, barrels or other containers mounted on skids designed to be handled by lift or hand trucks and delivered either directly to the shop floor or to stockrooms until ready for use. Careful study of material handling has shown that very few materials need be stored in stockroom bins, and the floor space occupied by stockrooms can be greatly reduced by these methods.

Many methods have been introduced for transferring material in the factory from one department to another, from one machine to the next, or in assembly lines. All of them have the common object of keeping the material moving steadily without being thrown into containers or upon the shop floor. Simple steel chutes can often be used for small parts where machines are placed close together. Larger parts can be handled better on movable racks, roller conveyors, belts or overhead chain-conveyors.

Light parts that require careful handling or that are used in small quantities can be stored in trays that can be racked one on top of another, or in standard-sized steel pans that will nest one on top of another, and can be handled on skids throughout the plant. When emptied, the racks or pans can be piled on the skids again to be returned to the stockrooms.

The machining or processing of parts throughout the plant presents a fascinating and never-ending study in production and cost reduction. New methods are soon discarded for still better ones, as improved machinery and higher efficiency on the part of the operators reduce the number of operations to be performed.

Production of New Designs

In the machining or processing of new parts, operations should be studied and reduced to the lowest number possible to produce the finished part; and the machinery should be so located as to enable an operator to handle as many machines as possible, with the least amount of walking or physical effort in the handling of materials.

Heavy materials should be handled by cranes, hoists or other mechanical means, which are faster and cheaper than labor. Jigs and fixtures should be carefully designed to require the least possible time for cleaning, loading and unloading, so as to take advantage of the full productivity of the machine. This is a matter that is frequently overlooked by tool engineers, resulting in slowing down production through an entire machine line. Rotating fixtures, that make it possible to load and unload the jigs while the machine operations are being performed, usually will greatly increase the productivity of the machine.

Space should be set aside at intervals in long machine lines containing many special machines, in which the breaking down of a machine or fixture might seriously cripple the whole plant, where small banks of materials at different stages of completion can be stored to be drawn on to maintain production in the line whenever repairs to machinery or tools may be necessary.

Great care should be given in the plant lay-out to locating all machining departments as conveniently as possible to assembling lines, so that the finished materials can be kept constantly moving and be delivered readily to the point on the assembling lines where they are to be used. Assembled units also should be delivered to the main car-assembly lines at the points where they are to be used, with as little trucking or handling as possible and at such a rate as to avoid delays on these lines, where a large number of men are usually employed.—From a paper by H. S. McClellan, superintendent of the Highland Park plant of Chrysler Motors, at a meeting of the Cleveland Section.

Personal Notes of the Members

Clements Elected Vice-President of A. S. T. M.

Frank O. Clements, technical director of the General Motors Corp. Research Laboratories, of Detroit, and a Member of the Society since 1918, was elected vice-president of the American Society for Testing Materials at the recent annual meeting of that society in Atlantic City.

A chemist of outstanding ability, Mr. Clements has been identified with research engineering for many years. He joined General Motors in 1920 as technical director of the corporation's research laboratories at Dayton, Ohio, and in 1926 transferred his headquarters to Detroit to take up the duties of his present position.

Mr. Clements became a member of the Dayton Section in 1922, and in 1926 transferred his Section affiliation to Detroit. He has been an interested cooperator in the work of the Society, having twice served on the Non-Ferrous Metals Division of the Standards Committee and this year being a member of the Publication Committee.

Mr. Clements is also a member of the American Chemical Society, the American Electrochemical Society, the Institute of Metals (British), the American Society for Steel Treating, the American Association for the Advancement of Science, the Detroit Engineering Society and the Dayton Engineers' Club.

Chase Joins American Machinist Staff

On July 1 Herbert Chase became an associate editor of *American Machinist*. Mr. Chase is well qualified, through his automotive and editorial experience, to take up the duties of his new post. In 1908, following his graduation from Sibley College, Cornell University, with the degree of mechanical engineer, he entered the service of the Automobile Club of America, in New York City, as laboratory engineer. While in this position he did much research work which brought his election to the honorary scientific Society of Sigma Xi. The Club laboratory was then the leading organization of this kind in this Country. In 1915 Mr. Chase was advanced to the position of chief engineer of the Club, but two years later he gave up this position to join the staff of the Society of Automotive Engineers as Assistant Secretary, and remained on the Society staff until 1920, when he became identified with the Power Plants Corp., in the City of Washington. Severing this connection one year later, he joined the Class Journal Co., in New York City. Shortly thereafter he was made engineering editor of *Automotive Industries*, and some three years later became manager of the research department of that publication. In 1925 he became affiliated with the Erickson Co., a New York advertising agency, from which he resigned late last year.

Mr. Chase is a member of long standing in the Society, having been elected to Member grade in 1910. His membership has been characterized by an unflagging interest in and enthusiastic support of Society work. His committee activities have been many and varied. He served eight terms on the Publication Committee, seven of them consecutively. He was a member of the Miscellaneous Division of the Standards Committee every year between 1910 and 1914, and was twice elected to membership on the Motor Testing Division. He also served two terms on the Nomenclature Division of the Standards Committee. In 1914 he acted as secretary of the National Nominating Committee; in 1917 he was chosen Treasurer of the Society, and in 1918 he contributed valued service as a member of the National Meetings Committee. He has twice been named Treasurer of the Metropolitan Section, of which he was a charter member.

HERBERT CHASE

Mr. Chase has contributed to Society literature many technical papers which have been of unusual interest and engineering merit and received international recognition. Among these papers, which were presented at various meetings of the Society and published in subsequent issues of THE BULLETIN, THE JOURNAL, and TRANSACTIONS, are: A Comprehensive Motor Test, Automobile Engine and Carbureter Testing, Magic Motor (written in collaboration with F. R. Hutton), Notes on Power Variation with Atmospheric Changes, An Ideal Car, Possibilities of the Constant-Pressure Cycle (written in collaboration with A. B. Browne), Automobile-Engine Cycles of the Future, Modern Aeronautic Engines, Practice and Theory in Clutch Design, A Critical Study of Modern Automotive-Vehicle Steering Systems, Automobiles of Today and Tomorrow, and Front Wheel Drives, Are They Coming or Going?

Meister Joins Curtiss Flying Service

Louis G. Meister, whose work in the engineering field has largely been devoted to aeronautics, recently assumed the position of vice-president and general manager of the Curtiss Flying Service of Ohio, with headquarters at Cleveland. This appointment followed Mr. Meister's resignation as sales manager of the Buhl Aircraft Co., of Marysville, Mich.

Prior to his affiliation with the Buhl Aircraft Co., upon which he entered three years ago, Mr. Meister served in the United States Army. He enlisted as a first lieutenant in the Engineering Division of the Air Service, at McCook Field, in 1917, just after finishing his studies at the Air Service Engineering School. In 1922 he was assigned to the duties of airplane test pilot and the following year was advanced to the rank of captain and appointed chief of the Airways Branch. In 1926 he severed his military ties to join the Buhl company.

Mr. Meister, who became a Service Member of the Society in 1920 and was transferred to Member grade in 1926, has held membership in the Dayton Section since 1922, serving as Section Secretary in 1925 and 1926. He is the author of a 1926 National Aeronautic Meeting paper, entitled Airplanes for Individual Ownership, which was published, together with discussion, in the March, 1927, issue of THE JOURNAL.

Harry G. Allen, formerly associated with the Motor Rim & Wheel Service,

(*Continued on p. 36*)

Applicants Qualified

The following applicants have qualified for admission to the Society between June 10 and July 10, 1929. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff.) Affiliate; (S M) Service Member; (F M) Foreign Member.

ADAMS, CLARK M. (M) vice-president, assistant general manager, Nagel Electric Co., 515 Hamilton Street, *Toledo, Ohio.*

ALDRICH, ROBERT (A) president, Flyers, Inc., Albany Airport, *Albany, N. Y.*

ALLEN, JOSEPH W. (M) engineering department, Eclipse Machine Co., 545 North Arlington Avenue, *East Orange, N. J.*

BAKER, MALVERN S. (J) draftsman, Bendix Brake Co., *South Bend, Ind.;* (mail) 720 Lincoln Way, West.

BALL, CRISSY K. (M) acting general factory manager, American LaFrance & Foamite Corp., *Elmira, N. Y.;* (mail) 1206 West Water Street.

BERGEY, MILTON D. (A) president, Campbell-Ewald, Ltd., 372 Bay Street, *Toronto, Ont., Canada.*

BERTRAN, EDWARD M. (M) chief engineer, Brewster & Co., Inc., *Long Island City, N. Y.*

BLOOD, ARTHUR R. (M) chief draftsman, chassis section, H. H. Franklin Mfg. Co., *Syracuse, N. Y.;* (mail) 448 Kirk Avenue.

BODE, LOUIS A. (A) service man, International Motor Co., 25 Broadway, New York City; (mail) 33 Second Avenue, *North Pelham, N. Y.*

BOWERS, GEORGE D. (A) distribution manager, Simms Oil Co., Magnolia Building, *Dallas, Tex.*

BRETH, J. P. (A) special representative, salesman, Wayco Oil Corp., 15th and Warren, West, *Detroit;* (mail) 2750 West Chicago Boulevard.

BROWN, MARCUS L., JR. (M) factory manager, Seiberling Rubber Co. of Canada, Ltd., 99 Paton Road, *Toronto, Ont., Canada.*

BUHLMANN, FRANK HENRY (M) chief engineer, Rollway Bearing Co., Inc., *Syracuse, N. Y.;* (mail) 541 Seymour Street.

CAESAR, O. S. (M) president, Motor Transit Management Co., 1157 South Wabash Avenue, *Chicago.*

CHASE, CHARLES H. (M) professor of steam engineering, Tufts College, Engineering School, Medford, Mass.; (mail) 39 Lincoln Street, *Stoneham, Mass.*

COWARDIN, HARRY ALFRED (M) mechanical engineer, Cowardin Mechanical Laboratory, 901 North 36th Street, *Richmond, Va.*

DAVIS, W. E. (M) assistant general manager, General Motors of Canada, Ltd., *Oshawa, Ont., Canada;* (mail) 399 Simcoe Street, North.

DAVIS, W. F. (M) chief engineer, in charge of powerplant development, Fairchild Engine Corp., *Farmingdale, L. I., N. Y.;* (mail) 176 Hallock Street.

DEAN, HUGH (A) manager, forge plant, Chevrolet Motor Co., 1901 East Euclid Avenue, *Detroit;* (mail) Detroit Athletic Club

DE GIULIANI, HENRY (M) engineer, A. E. Rockwell Laboratory, Long Island City, N. Y.; (mail) General Delivery, *Folyet, Ont., Canada.*

DI GIOVANNI, LOUIS (M) systematizer, planning department, Edward G. Budd Mfg. Co., 12141 Charlevoix Avenue, *Detroit;* (mail) 3551 Dickerson Avenue.

DOUGHERTY, JAMES THOMAS (M) vehicular supervisor, Bakeries Service Corp., 6025 South St. Andrews Place, *Los Angeles.*

DOYLE, FRANK B. (M) designer, Ingersoll-Rand Co., *Phillipsburg, N. J.*

DREW, GARVIN (J) sales, service, branch office, A. Schrader's Sons, Inc., 470 Vanderbilt Avenue, Brooklyn, N. Y.; (mail) 12-221 General Motors Building, *Detroit.*

EARL, HARRY W. (A) president, chief engineer, Earl Aircraft Corp., 277 Hawthorne Avenue, *Portland, Ore.*

EISENMANN, SAMUEL B. (J) student, New York University, University Heights, New York City; (mail) 128 Elmwood Avenue, *Bogota, N. J.*

ENGELHARDT, PAUL (F M) general manager, Rochet-Schneider, 57 Chemin Feuillat, Lyons, France; (mail) 12 Chemin Street, *Alban, Lyons, France.*

FABLE, CHARLES E. (A) service manager, Kings County Buick, Inc., 44 Empire Boulevard, *Brooklyn, N. Y.*

FANNING, GEORGE H. (A) New York representative, Fate-Root-Heath Co., Plymouth, Ohio; (mail) Room 367, 50 Church Street, *New York City.*

FUHRY, EDMUND (M) supervisor, dynamic laboratory, Olds Motor Works, *Lansing, Mich.;* (mail) 800 Sparrow Avenue.

GAFFKE, WILLIAM J. (A) foreman, Houdaille Engineering Co., *Buffalo;* (mail) 134 Lafayette Avenue.

GOSHIMA, SADAJI (M) sales engineer, exporting aeronautical equipment and automobiles, Mitsubishi Co., 120 Broadway, *New York City.*

GOSSARD, ALVIN H. (M) manager, automotive department, Middle West Utilities Co., 72 West Adams Street, *Chicago.*

GOULD, WILLIAM CRACKEL (J) service department, Pratt & Whitney Aircraft Co., Hartford, Conn.; (mail) 142 Four Mile Road, *West Hartford, Conn.*

GRIGSBY, HOWARD RAY (M) superintendent of transportation, Oklahoma Gas & Electric Co., 321 North Harvey Street, *Oklahoma City, Okla.;* (mail) 121 West 28th Street.

GRINHAM, EDWARD GEORGE (F M) chief designer, design department, Humber, Ltd., *Coventry, England.*

HALL, RANDOLPH F. (M) vice-president, chief engineer, Cunningham-Hall Aircraft Corp., 13 Canal Street, *Rochester, N. Y.*

HANSEN, O. ARNOLD (J) automotive engineer, Linde Air Products Co. Laboratory, 169 Chandler Street, *Buffalo.*

HANSON, HARRY IRVIN (A) tool-maker, assistant foreman, Johnson Piston Ring Co., 6010 Woodward Avenue, Detroit; (mail) 21 Ingram, *Plymouth, Mich.*

HAWORTH, HAROLD FIRTH (F M) chief engineer, Leyland Motors, Ltd., *Leyland, Lancashire, England.*

HAWTHORNE, LEO S. (M) lubricating engineer, Sinclair Refining Co., 370 Seventh Avenue, New York City; (mail) 4601 Chester Avenue, *Philadelphia.*

HAZEN, GEORGE W. (A) maintenance manager, Uppercu-Cadillac Corp., 197 South Broadway, *Yonkers, N. Y.*

HERGENROETHER, ERNST J, (M) automotive research and development department, International Nickel Co., *Detroit;* (mail) 12074 Pinehurst Street.

HOGBEN, WILLIAM H. (A) sales manager, Ditzler Color Co., division of Pittsburgh Plate Glass Co., 8000 West Chicago Boulevard, *Detroit.*

HOPKINS, THOMAS (A) foreman inspection division, General Motors of Canada, *Oshawa, Ont., Canada;* (mail) 62 Emma Street.

IHRIG, A. HENRY (J) designer, draftsman, Olds Motor Works Design Engineering Department, Olds Avenue, *Lansing, Mich.*

JONES, IRA MILTON (A) patent lawyer; 68 East Wisconsin Avenue, *Milwaukee.*

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LANGE, G. M. (J) service department, Timken Roller Bearing Co., *Canton, Ohio.*

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MACKENZIE, A. K. (J) service manager, Massy, Ltd., 35 Marine Square, *Port-of-Spain, Trinidad, British West Indies.*

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MCELROY, BERNARD M. (A) salesman, Hoover Spring Co., 201 Franklin Street, *San Francisco.*

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MOONEY, A. W. (J) president, Mooney Aircraft Corp., *Wichita, Kan.*

MORTON, HUDSON T., JR., (M) metallurgist, Hoover Steel Ball Co., *Ann Arbor, Mich.;* (mail) 1125 Ferdon Road.

MUENCH, GEORGE (A) automotive engineer, Georgia Power Co., Electric Building, *Atlanta, Ga.*

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NYGREN, ERNEST E. (M) chief draftsman, Leece-Neville Co., *Cleveland;* (mail) 1000 Dillewood Road.

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PETERSEN, NEIL P. (M) works manager, Canadian Acme Screw & Gear, Ltd., 1209 King Street West, *Toronto, Ont., Canada.*

PETERSON, NORMAN H. (A) general manager of service, Packard Motor Car Co. of Chicago, 306 West 37th Street, *Chicago.*

PORTER, LEMUEL (M) expert layout draftsman, head of flat-pattern drafting department, Curtiss Aeroplane & Motor Corp., Garden City, L. I., N. Y.; (mail) Rhodes Avenue, *Hempstead, L. I., N. Y.*

POTTS, ALLEN D. (M) metallurgist, Simonds Saw & Steel Co., Ohio Street, *Lockport, N. Y.;* (mail) Box 358.

READ, AUGUSTUS LEE (A) president, Meehanite Metal Engineering Corp., 907 Chamber of Commerce Building, *Cincinnati.*

REDMOND, ALBERT G. (A) owner, A. G. Redmond Co., *Flint, Mich.;* (mail) 1109 Stewart Avenue.

REID, F. MALCOLM (M) chief engineer, Fruehauf Trailer Co., 10940 Harper Avenue, *Detroit;* (mail) 5912 Lakeview Avenue.

RICHARDSON, HENRY MARTYN (J) engineer, textolite division, industrial engineering department, General Electric Co., 920 Western Avenue, *Lynn, Mass.*

RIORDAN, KEITH (F M) manager service and technical departments, Autocar Industries Proprietary, Ltd., 104 Russell Street, *Melbourne, Victoria, Australia.*

ROHRBACHER, EARL W. (J) engine design draftsman, Hupp Motor Car Corp., *Detroit;* (mail) 151 Seward Avenue.

RUSSELL, LINUS E. (J) president, Peters & Russell, Inc., 302 Tecumseh Building, *Springfield, Ohio.*

SANDER, J. W. (J) planning department, Fokker Aircraft Corp. of America, *Glendale, W. Va.*

SCARTH, WILLIAM MONTEITH (J) engineer, specification department, chassis section, General Motors Co. of Canada, *Oshawa, Ont., Canada;* (mail) 70 Simcoe Street, North, Apartment No. 3.

SCHAEFER, RAYMOND F. (J) sales training course, The Buda Co., *Harvey, Ill.;* (mail) 15420 Myrtle Avenue.

SCHAEFLE, A. J. (A) parts and service manager, Olds Motor Works, 1540 Market Street, *San Francisco.*

SCHEBERA, ERNST (M) president, general manager, Fleetwood Body Corp., 10 East 57th Street, *New York City.*

SCHROYER, LEWIS A. (A) superintendent of maintenance, Yellow Cab Co., 245 Turk Street, *San Francisco.*

SICKLER, JOHN MEHARRY (J) research assistant, Purdue University Engineering Experiment Station, West Lafayette, Ind.; (mail) 226 South Ninth Street, *Lafayette, Ind.*

SIEDSCHLAG, KARL G. (M) industrial engineer, American Hard Rubber Co., Seiberling and Englewood Streets, *Akron, Ohio.*

SIROTEK, JOSEPH (A) president, general manager, Illinois Auto Electric Co., 2450 Calumet Avenue, *Chicago.*

SLAUGHTER, SAM C. (M) manager, vocational division, The White Co., Thompson Avenue and School Street, *Long Island City, N. Y.*

SMITH, S. HAROLD (J) experimental engineer, automotive division, Smith Incubator Co., 3108 West 121st Street, *Cleveland;* (mail) 16507 Ernest Avenue.

SMITH, STANFORD ALLEN (M) John Warren Watson Co., 3081 Grand Boulevard, East, *Detroit.*

SNIDOW, ROBERT C., CAPT. (S M) student, United States Army, Camp Holabird, Baltimore; (mail) Coast Artillery School, *Fortress Monroe, Va.*

SOUTTER, ARTHUR W. (A) maintenance engineer, Rolls-Royce of America, Inc., Page Boulevard, *Springfield, Mass.*

STAHL, LAWRENCE C. (A) salesman, Neafie & Fanning, 50 Church Street, *New York City.*

STIEBER, HERMAN L. (M) senior inspector of Naval material, United States Navy, Bureau of Aeronautics, Navy Department, Wright Aeronautical Corp., Paterson, N. J.; (mail) 37 Laura Avenue, *Nutley, N. J.*

STILLMAN, HARRY M. (M) manager, Detroit branch, North East Electric Co., Rochester, N. Y.; (mail) 4473 Cass Avenue, *Detroit.*

STRUSS, O. A. (A) service manager, Mansfield Chevrolet Co., Vancouver, Wash.; (mail) 1476 Kerby Street, *Portland, Ore.*

THOMAS, FRED H. (A) foreman, electric department, Spaulding Auto Electric Co., Box 1371, *Phoenix, Ariz.*

THOMPSON, JOSEPH R. (M) Fokker Aircraft Corp., Hasbrouck Heights, N. J.; (mail) 5 Pangborn Place, *Hackensack, N. J.*

TRIPP, HARRY F. (A) brake expert, 564 20th Street, *Oakland, Calif.*

VERBSKY, LOUIS H. (A) president, general manager, Euclid Wood Products Co., 19422 Nottingham Road, *Cleveland.*

VIDICAN, JOHN P. (J) complete automobile body designer, Oakland Motor Car Co., Pontiac, Mich.; (mail) 450 Y. M. C. A., *Highland Park, Mich.*

VILLIGER, HERMAN J. (J) inspector and service salesman, Studebaker Sales Co. of Chicago, 4635 Washington Boulevard, *Chicago;* (mail) 3055 West 55th Street.

WARD, ROSS N. (A) service superintendent, Mack International Motor Truck Corp., 285 Oregon Street, *Portland, Ore.;* (mail) 620 Wasco Street.

WHITACRE, WILLIAM HENRY (M) mechanical engineer, in private work; (mail) 2884 Coleridge Road, *Cleveland.*

WHYTE, JESSEL S. (M) vice-president, general manager, Mac Whyte Co., *Kenosha, Wis.*

WIEDEN, CAMILLO (J) designer, engineer in charge, American Aeronautical Corp., Cross Island Boulevard, *Whitestone, L. I., N. Y.;* (mail) 149-155 18th Avenue.

WILL, WALTER O. (M) sales engineer, Cramp Mfg. Co., 2850 West Fulton Street, *Chicago;* (mail) 5015 West Erie Street.

WILLIS, FRANK B. (A) general sales manager, Bragg-Kliesrath Corp., Queens Boulevard and Harold Avenue, *Long Island City, N. Y.*

WYSOR, HENRY (M) metallurgical engineer, Bethlehem Steel Co., East Third Street, *Bethlehem, Pa.*

Standardization Activities

(*Concluded from p.* 181)

C. R. Alden, Ex-Cell-O-Tool & Mfg. Co.
C. R. Briney, Jig Bushing Co.
A. C. Danekind, General Electric Co.
J. H. Horigan, Union Twist Drill Co.
W. C. Mueller, Western Electric Co.
C. E. Rundorff, Buick Motor Co.
F. S. Walters, Westinghouse Electric & Mfg. Co.
H. C. McKean, Standard Tool Co.

Key-Slot Cutter Report

THE S.A.E. Production Engineering Standard for Woodruff Key-Slot Cutters, which was formulated in conjunction with the revised S.A.E. Standard for Woodruff Keys and adopted by the Society at the Semi-Annual Meeting at Saranac Inn, has been published in whole as a separate pamphlet and by reference in the July Supplement to the 1929 edition of the S.A.E. HANDBOOK. This report should be used in conjunction with the standard for Woodruff Keys that is published in full in the Supplement mentioned.

In accordance with the procedure already established, copies of the standard for cutters will be sent automatically to only those members of the Society who have already indicated their desire for the Production Engineering Standards. However, as this standard probably is of direct interest to a larger number of the Society members, all who desire a copy are requested to notify the Standards Department of the Society at the New York office, 29 West 39th Street, New York, as promptly as possible, and copies will be mailed to them at once.

Applicants for Membership

The applications for membership received between June 15 and July 15, 1929, are listed below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

ALTREE, A. C., manager manufacturers sales, Pacific Coast division, American Bosch Magneto Corp., *San Francisco.*

ANDERSON, O. M., secretary-treasurer, Northern Automotive Supply Co., *Bay City, Mich.*

ASAI, KIKUSABURO, 1702 Geddes Avenue, *Ann Arbor, Mich.*

BIGELOW, ANSON A., vice-president, Black & Bigelow, Inc., *New York City.*

BOBEK, WILLIAM, draftsman, Fisher Body Corp., *Detroit.*

BREWSTER, DONALD R., field engineer, National Lumber Manufacturers Association, *Memphis, Tenn.*

BRENNER, HERBERT J., district manager, Willis-Jones Machinery Co., Inc., *Milwaukee.*

CALVERT, CHARLES E., shop foreman, Browning Auto Co., *Seattle, Wash.*

CATCHPOLE, JAMES A., service manager, Cole Chevrolet Motors, Inc., *Utica, N. Y.*

CLARKE, NOEL LANGTON, assistant manager, truck delivery division, T. Eaton Co., Ltd., *Toronto, Ont., Canada.*

CLISSOLD, EDWARD M., manufacturers representative, Detroit district, Firestone Steel Products Co., *Akron, Ohio.*

COFFEY, JAMES F., 20 Cox Avenue, *Yonkers, N. Y.*

CRAINE, EDGAR W., owner, Edgar W. Craine Co., *Los Angeles.*

DAVIDSON, W. W., vice-president, Rex Products & Mfg. Co., *Detroit.*

DRANGEID, RAGNVALD O., automobile body designer, Cadillac Motor Car Co., *Detroit.*

FOSTER, H. TORREY, research statistical engineer, Thompson Products, Inc., *Detroit.*

GERKER, B. H., engineer, Chevrolet Motor Co., *Flint, Mich.*

GLICKMAN, MENDEL, mechanical engineer, International Harvester Co., *Milwaukee.*

GUINSBOURG, WLADIMIR, engineer, Fabrique Nationale d'arms de Guerre, Herstallez, *Liege, Belgium.*

GUREASKO, EDWARD MARTIN, sub-foreman, motor and electrical installations, Curtiss Aeroplane & Motor Co., *Far Rockaway, L. I., N. Y.*

HALL, FRANK W., designing and production engineer, Automat Drive & Transmission Co., *Philadelphia.*

HALLER, AUGUSTINE C., 616 Washington Road, South Hills, *Pittsburgh.*

HAMMOND, CHARLES F., JR., sales engineering, Gemmer Mfg. Co., *Detroit.*

HANCOCK, G. A., chief engineer, L. H. Gilmer Co., Tacony, *Philadelphia.*

HEATH, J. M., layout and design, Mercury Aircraft Corp., *Hammondsport, N. Y.*

HEIGHT, LEWIS H., chief engineer, Mooney Aircraft Corp., *Wichita, Kan.*

HOLST, CARLOS BERNARD, manager mechanical service department, Inter-Mountain Electric Co., *Salt Lake City, Utah.*

INGLIS, J. W., assistant foreman, electric repair department, Begg Bros., Ltd., *Vancouver, B. C., Canada.*

JOHNSON, ANDOR W., in charge of dynamometers, Eisemann Magneto Corp., *Brooklyn, N. Y.*

JOHNSON, THEODORE S., automotive engineer, Vacuum Oil Co., *New York City.*

JONES, E. C., chief draftsman, Wilcox-Rich Corp., Marshall Division, *Marshall, Mich.*

KRAEBLING, HARRY A., president, Standard Steel Propeller Corp., *Homestead, Pa.*

LAMB, WARD E., truck and motorcoach layout and detail design, G. H. Will Motors Corp., *Minneapolis.*

LAUTZ, CARL F., installation engineer, Houpe Engineering Corp., *Buffalo.*

LANQUIST, WILTON G., engineering department, Wright Aeronautical Corp., *Paterson, N. J.*

MACGREGOR, JOHN RYLE, research engineer in charge of products testing, Standard Oil Co. of California, *Richmond, Calif.*

MAHLE, ERNST, managing director, Elektronmetall Corp., *Stuttgart, Germany.*

MAKELIM, HOWARD G., proprietor, Magneto Repair Co., *San Francisco.*

MERRIMAN, CLARENCE H., machine design and plant layout engineer, Mueller Brass Co., *Port Huron, Mich.*

MILLS, ROBERT C., superintendent, Manufacturers Foundry Co., *Waterbury, Conn.*

MOSSOP, ADELBERT, automobile mechanic, Klinger Brothers, The Bronx, *New York City.*

NAPTHALI, CLIFFORD H. A., engineer, National Roads & Motorists Association, *Sydney, New South Wales, Australia.*

PEPPERS, CHARLES C., general supervision of manufacturing, sales and purchases, Champlain Refining Co., *Enid, Okla.*

POWELSON, W. E., master mechanic, Los Angeles County Hall of Records, *Los Angeles.*

PROUDFOOT, DAVID GIBB, assistant research engineer, Sun Oil Co., *Philadelphia.*

ROSENKRANZ, L. J., educational director, National Automotive and Electrical School, *Los Angeles.*

ROSA, LEONARD J., general sales manager, Kelsey-Hayes Wheel Corp., *Detroit.*

SCHOLL, L. R., service manager, Sterling Motor Co. of California, *San Francisco.*

SEASHORE, CARL G., JR., city sales, The White Co., *Omaha.*

SHERMAN, D. W., mechanical engineer, A. O. Smith Corp., *Milwaukee.*

SPEER, VERNON D., chief engineer and manager, Aero Development Co., *Cedar Falls, Iowa.*

STORY, CHASE S., co-partner, designing wood aircraft propellers, Story-Gowley Co., *Glendale, Calif.*

THORNE, NIBLACK, secretary-treasurer, Thorne Motor Corp., *Chicago.*

TROLLOPE, CHARLES HENRY, service representative, H. B. Phipps, *Sydney, Australia.*

ULLBERG, FRED, JR., assistant engineer, New Era Motors Corp., *New York City.*

VAN DEURS, WILLIAM, draftsman, Ford Motor Co., *Dearborn, Mich.*

VIEIRA-RIBEIRO, ALBERTO A., service manager, Wallace Harper & Co., Ltd., *Kowloon, Hong-Kong, China.*

VOGT, CARL J., instructor, mechanical engineering, University of California, *Berkeley, Calif.*

VOIGT, ALBERT G., mechanical engineer, draftsman, American Car & Foundry Co., *New York City.*

WARDWELL, JOHN S., sales representative, Timken-Detroit Axle Co., *Detroit.*

WEISS, JOHN E., chief draftsman, E. T. Birdsall, *Hackensack, N. J.*

WERMINE, H. H., research engineer, Belden Mfg. Co., *Chicago.*

WHITEMAN, J. ROBERT, assistant to engineer, Aircraft Development Co., *Grosse Ile, Mich.*

WILCOX, JOHN, general purchasing agent, The Pickwick Corp., *Los Angeles.*

Notes and Reviews

AIRCRAFT

Simple Aerodynamics. By C. N. Monteith. Published by the Ronald Press Co., New York City; 418 pp., 211 illustrations. [A-1]

The third revision of Mr. Monteith's well-known book has been prepared by Col. C. C. Carter, who has had eight years' experience in teaching the subject of aerodynamics at the United States Military Academy at West Point, N. Y.

The treatment of the subject is not highly technical yet is suitable for use in elementary courses in technical institutions and also for home-study use by individuals. Fundamental principles are developed and applied and a considerable amount of descriptive matter has been added, together with new material on navigation, radio and aerial photography. Supplementary chapters on materials and construction, equipment, navigation, and the military airplane have been contributed by technical specialists of the Air Corps of the Army.

Airplane Structures. By Alfred S. Niles and Joseph S. Newell. Published by John Wiley & Sons, Inc., New York City; 413 pp., illustrated. [A-1]

In the preparation of this book the authors had a two-fold purpose: to supply the need for a textbook for courses in airplane structures and to satisfy the ordinary requirements of the practising engineer. As a textbook, this volume is intended for use by students who are well grounded in the mechanics of materials and in calculus, and it contains all the structural theory and scientific data for the structural design of airplanes.

Emphasis is placed on the theory of stress-analysis operations, and the methods for determining the stresses in the members and the allowable stresses in the more common materials are completely described by means of tables, charts and design data. A chapter is devoted to weight estimation and contains tables of weights of materials and equipment used in airplanes, together with recommendations as to the making of preliminary weight estimates. An effort is also made to enable the student to profit by past experience, special note being made of situations in which designers have frequently used incorrect methods of analysis.

Airplane Stress Analysis. By Alexander Klemin. Published by The Ronald Press Co., New York City; 277 pp. [A-1]

"This book has been prepared as an introductory treatise on the art of airplane stress analysis," states the preface. It is therefore specially useful to the college student or to engineers and designers who want a complete yet simple treatment of the subject. The book covers the stress requirements of the Department of Commerce, particularly as regards the small commercial airplane. The rules of the Department are presented in a form that can be readily understood, and advanced mathematics have been avoided as far as possible.

A preliminary review takes up the principles of applied mechanics, and the application of the formulas thus developed to the calculation of airplane stresses is shown by using a hypothetical airplane as an illustration. All calculations are carried through much as an actual analysis is made for submission to the Department of Commerce. A valuable feature is the inclusion of information regarding the materials employed in aircraft construction.

Strain Energy Methods of Stress Analysis. By A. J. Sutton Pippard. Published by Longmans, Green & Co., New York City; 146 pp., illustrated. [A-1]

This is another book which has been prepared primarily for the use of students of engineering but in such form as to be generally acceptable also to engineers engaged in structural work who desire a sound knowledge of those methods of stress analysis due originally to Castigliano.

These methods are being used increasingly as modern practice demands the scientific estimation of the stress involved, particularly in aircraft.

The book is divided into two parts, the first part consisting of the theory of the method and of statements and proofs of the essential elastic theorems, while the second part contains a number of illustrative examples, worked out in detail, which are chosen to exemplify the various kinds of problems that may be attacked by strain-energy methods.

Fundamentals of Fluid Dynamics for Aircraft Designers. By Max M. Munk. Published by the Ronald Press Co., New York City; 198 pp. [A-1]

The author has specialized on aerodynamics for 12 years, during which he conducted many experiments to test various theories and developed a considerable number of methematical formulas to explain phenomena observed in research and flight tests. The results appeared in more than 75 publications. This book aims to present the more useful data from that material, coordinated from a uniform viewpoint and in the light of more recent simplifications of the earlier mathematical expressions.

This volume should be of interest to the advanced student and to the aeronautic engineer and designer.

The Pressure Distribution Over the Horizontal and Vertical Tail Surfaces of the F6C-4 Pursuit Airplane in Violent Maneuvers. Report No. 307. By R. V. Rhode. Published by the National Advisory Committee for Aeronautics, City of Washington; 20 pp., illustrated. [A-1]

The investigation reported herein was conducted by the National Advisory Committee for Aeronautics, at the request of the Bureau of Aeronautics of the Navy Department, for the purpose of determining the maximum loads likely to be encountered on the tail surfaces in flight. The information is a part of that needed for a revision of existing loading specifications to bring these into closer agreement with actual flight conditions. A standard F6C-4 airplane was used and the pressure distribution over the right horizontal and complete vertical tail surfaces was recorded throughout violent maneuvers. The results show that the existing loading specifications do not conform satisfactorily to the loadings existent in critical conditions and in some cases were exceeded by the loads obtained.

An acceleration of 10.5 *g* was recorded in one maneuver, in which the pilot suffered severely; it is therefore

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These items, which are prepared by the Research Department, give brief descriptions of technical books and articles on automotive subjects. As a general rule, no attempt is made to give an exhaustive review, the purpose being to indicate what of special interest to the automotive industry has been published.

The letters and numbers in brackets following the titles classify the articles into the following divisions and subdivisions: *Divisions*—A, Aircraft; B, Body; C, Chassis Parts; D, Education; E, Engines; F, Highways; G, Material; H, Miscellaneous; I, Motorboat; J, Motorcoach; K, Motor-Truck; L, Passenger Car; M, Tractor. *Subdivisions*—1, Design and Research; 2, Maintenance and Service; 3, Miscellaneous; 4, Operation; 5, Production; 6, Sales.

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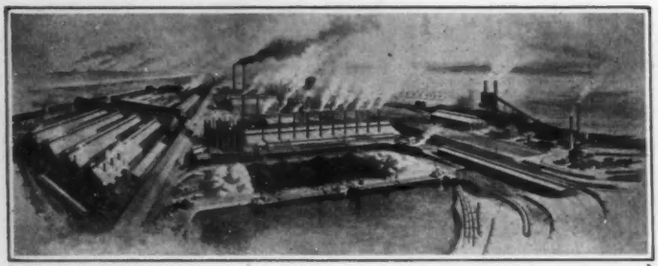

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Notes and Reviews

Continued

indicated that the limits of physical resistance of the pilot to violent maneuvers are being approached.

Navy specifications for the structural design of tail surfaces are included as an appendix.

Aerodynamic Characteristics of Airfoils—VI. Report No. 315. Published by the National Advisory Committee for Aeronautics, City of Washington; 35 pp., illustrated. [A-1]

This collection of data on airfoils has been made from the published reports of a number of the leading aerodynamic laboratories of this Country and Europe. The information, which was originally expressed according to the different customs of the several laboratories, is presented in a uniform series of charts and tables suitable for the use of designing engineers and for purposes of general reference.

Strength of Tubing Under Combined Axial and Transverse Loading. By L. B. Tuckerman, S. N. Petrenko, and C. D. Johnson.

Pressure Distribution on a Slotted R.A.F.—31 Airfoil in the Variable-Density Wind-Tunnel. By Eastman N. Jacobs.

Correcting Engine Tests for Humidity. By Donald B. Brooks. Technical Notes Nos. 307, 308 and 309 respectively. Published by the National Advisory Committee for Aeronautics, City of Washington. [A-1]

The limited space available in this number of THE JOURNAL, together with an unusual amount of aeronautic literature received for review during the last month, makes it necessary only to mention these three N.A.C.A. publications.

Technical Memoranda Nos. 516, 517, 518, 519 and 520. Published by the National Advisory Committee for Aeronautics, City of Washington. [A-1]

Translations of the following articles have been issued during June by the N.A.C.A.:

Crankcase Scavenging of Two-Stroke-Cycle Engines. By Hans List. Translated from *Zeitschrift des Vereines deutscher Ingenieure*, Feb. 16, 1929.

Investigation of the Effect of the Fuselage on the Wing of a Low-Wing Monoplane. By H. Muttray. Translated from *Luftfahrtforschung*, June 11, 1928.

Investigation of Atomization in Carbureters. By J. Sauter. Translated from *Zeitschrift des Vereines deutscher Ingenieure*, Nov. 3, 1928.

Force Measurements on Airplanes. By F. Seewald. Translated from *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, Oct. 7, 1928.

Torsional Rigidity of Cantilever Wings with Constant Spar and Rib Sections. By Giuseppe Gabrielli. Translated from *Luftfahrtforschung*, June 26, 1928.

Weight of Aircraft. By T. M. Barlow. Published in *The Journal of the Royal Aeronautical Society*, April, 1929, p. 239. [A-1]

The remark of a well-known British constructor that he "would spend a pound to save a pound any time" is chosen by Major Barlow to express the economic trend that weight in aircraft is assuming. In his paper he summarizes the various characteristics and influences affecting the weight of aircraft, and reviews the possible development with increased size. He considers first the influence of weight on performance of airplanes of (*a*) fast types, such as single-seat fighters and high-speed day bombers, (*b*) medium-speed types, such as general-purpose military aircraft, and (*c*) slower-speed types, such as large flying-boats, heavy bombers and commercial aircraft. The safety factor is the

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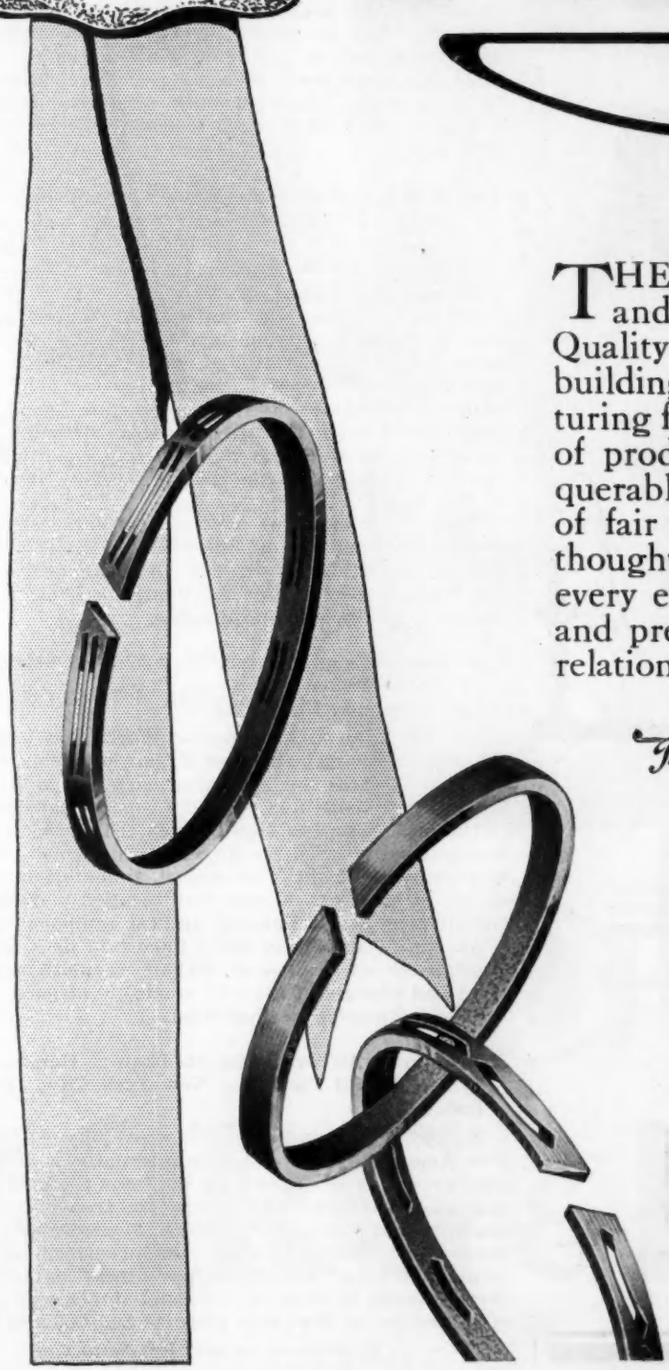

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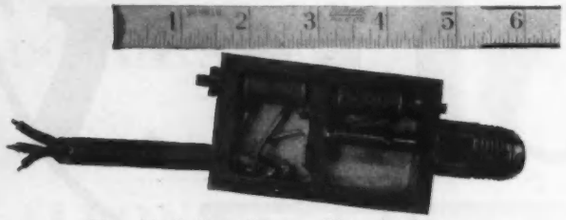
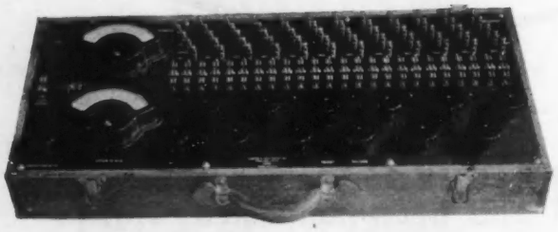
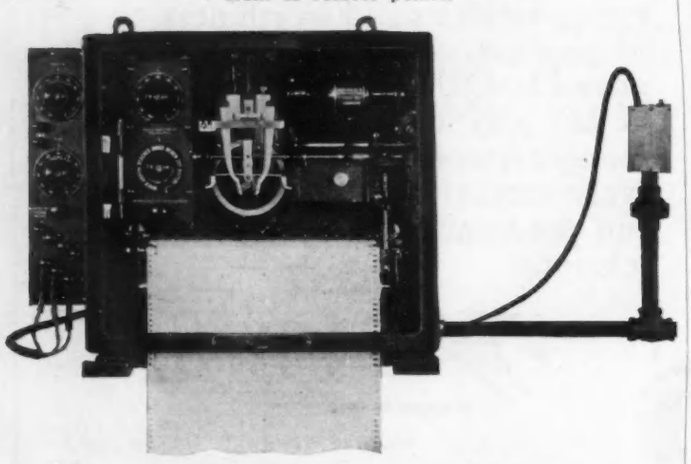


The McCollum-Peters Electric Pressure Transmitter.



Twelve-element panel board, for indicating pressures transmitted from 12 remote points.



Electric Pressure Transmitter installed in a pipe line for obtaining a record of the varying pressures in the line by means of a Leeds & Northrup Potentiometer Recorder.

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Notes and Reviews

Continued

second consideration. Materials and wheels are briefly covered in their connection with the weight of the entire plane; and the power unit is considered in detail under the headings, (*a*) engines and (*b*) airscrews. A concluding section deals with the influence of size on weight.

Aircraft Year Book, 1929. Published by the Aeronautical Chamber of Commerce of America, Inc., New York City; 484 pp., illustrated. [A-3]

The eleventh edition of the Aircraft Year Book reviews a most important epoch in the history of aviation. The year 1928 found American aviation, including not only flying but also the manufacture of equipment and the development of airports and airways, assuming the proportions of a major industry. The public began to take a personal interest in every phase of aeronautics; the air-transport lines extended their services in every direction; they flew twice the mileage of the preceding year and carried three times the quantity of mail and more than four times the number of passengers. The Year Book is an invaluable record and source book of information for anyone interested in things aeronautic.

The Second Report of the Daniel Guggenheim Fund for the Promotion of Aeronautics, 1928. New York City; 34 pp. [A-3]

"Probably the outstanding aeronautical achievement of 1928 was the demonstration in America by private enterprise that air transport can be made a profitable business without Government subsidy," states the report. In line with this change in status of commercial aviation, the Fund has withdrawn its assistance in arousing public interest in aviation and has resolved to concentrate upon the scientific problems involved in the mechanical structure of the airplane and the study of environmental conditions necessary for safe operation, particularly meterology and the problem of fog-flying.

The report mentions several new enterprises that may eventually continue of themselves: the first adequate weather-reporting service for American aviation, the first full-flight laboratory for fog-flying, and the first National Safety Conference in Aeronautics.

Civil Airports and Airways. By Archibald Black. Published by the Simmons-Boardman Publishing Co., New York City; 238 pp., illustrated. [A-4]

Mr. Black, an air-transport engineer, has prepared, with the help of 19 specialists on airport problems, an uptodate complete treatise on American airports, written in non-technical language and from the commercial viewpoint.

The book describes step by step the method of providing a municipality with an airport; what constitutes a good location, size of the plot needed, preparation of the field, layout of buildings, airway identification markings, runway requirements, night lighting, and the equipment needed.

An appendix contains many important data, including the Department of Commerce airport regulations, and rules, rates and charges of a model municipal airport. The entire volume is abundantly illustrated.

International Airports. By Stedman S. Hanks. Published by the Ronald Press Co., New York City; 195 pp., illustrated. [A-4]

Europe has led in air passenger-traffic up to the present. Few American airports handle international traffic, but the number is certain to increase, declares the author, as mail, express matter and passengers are transported in larger amounts and numbers to Canada, Mexico, the West Indies, Central and South America. Experience in operating international air-services is Europe's most marked advantage over America in aviation. Colonel Hanks's prolonged tour of inspection of European airports and his intimate knowl-

(*Continued on next left-hand page*)

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Notes and Reviews

Continued

edge of airport conditions at home make him especially well fitted to present this comparison of the design, construction, and management of the outstanding European and American airports.

In his book the author discusses passenger facilities at airports, tickets, baggage regulations, transportation of passengers to and from airports, and other details of European practice. He also considers the problem of developing transportation of freight by air and tells what has been done in Germany in the inauguration of combination air and rail service for express shipments.

Airplane Transportation. By James G. Woolley and Earl W. Hill. Published by the Hartwell Publishing Corp., Hollywood, Cal.; 353 pp. [A-4]

In the autumn of 1927 the faculty of the University of Southern California decided that increasing popular interest in airplane transportation warranted the development of a non-technical course which would appeal to those interested in the business elements of this new industry. Since there were no texts of the general nature required, the course was first given as a series of lectures and papers by nationally recognized leaders in this field. This material has been compiled in the present volume. Some of the more important classifications of the material are: operation, costs in operation, and training of personnel; airways and airports; mail, passenger and express service and rates; aviation insurance; meteorology; Government regulations; and investment and speculation.

The course is said to have proved exceedingly popular and as a non-required subject has attracted a record enrollment.

Die Sicherheit Im Luftverkehr auf Grund der Betriebsergenbnisse der Deutschen Luft Hansa, 1926-1928. By Erhard Milch. Published by the Deutschen Luft Hansa, 78 pp. [A-4]

This booklet presents for the first time, states the preface, a comprehensive view of the extent to which German air transport has attained the desired goal of reliability.

Detailed tables picture the operations of the Deutsche Luft Hansa for 1926, 1927 and 1928. Figures are given on such items as length of routes, number of miles flown, loads carried, extent to which schedules were adhered to and reasons for failures, number of forced landings and the reasons for them, accidents and their causes, injuries and fatalities to persons, apportionment of injuries to persons as between single and multi-engined planes, and the condition of craft and engines.

The figures show that during the last three years the frequency of injuries to persons has decreased sharply, and that the frequency of such interruptions in scheduled operations as might have given rise to injuries to persons, such as breakdowns and forced landings, has been lowered. Unfavorable weather took first place as a disrupter of schedules, while the most important single source of personal injuries was engine trouble, with the weather following second.

A discussion is given of various expedients used to increase the safety of air transport, covering personal organization, aircraft construction, engines and instruments. What is still lacking to perfect operating conditions is pointed out, and the ways in which defects may be overcome are outlined.

Die Befeuerung von Nachtflugstrecken. By Max J. Luber. Published in *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, May 28, 1929, p. 246. [A-4]

After a general discussion of the necessity of airway lighting for night flying, a description is given of lighting

(*Continued on next left-hand page*)

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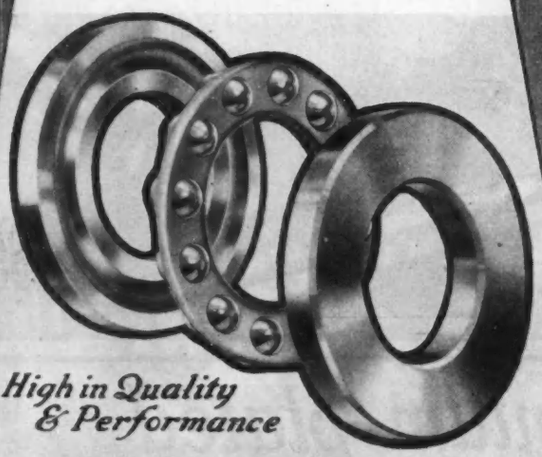

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Personal Notes of the Members

Continued

equipment, especially that in which revolving lights are used.

Attention is concentrated on the Berlin-Königsberg and the Berlin-Hanover routes, which have recently been provided with beacons. The system used is that developed by two years of experimentation on the Berlin-Hamburg and Berlin-Warnemünde routes, and the author notes as a point of interest that the results arrived at in Germany are the same as in this Country where the same conditions were to be met.

In addition to describing the lights, the author discusses their operation and certain optical factors influencing their effectiveness.

CHASSIS PARTS

La Suspension et les Problèmes qu'elle Soulève. By de Ram. Published in *Journal de la Société des Ingénieurs de l'Automobile*, April, 1929, p. 636. [C-1]

French automotive engineers, forced thereto by the exceedingly poor condition in which the war left the roads of France, have devoted much effort toward improving the riding-qualities of their cars.

The French technical press has evinced much interest in the theories advanced and the results achieved by de Ram, who summarizes them in this article. He points out that a fourfold goal is to be aimed at: easy riding on a smooth road; comfort in bad going; the ability to hold the road, especially at high speed; and reliable steering, free from reaction in the steering-wheel. The problem is complicated by three elements of flexibility present in the car, the springs, the tires and the chassis. The author dwells on all three factors, emphasizing particularly the advisability of more rigid chassis.

Two principles underlie the solution advanced: first, the supreme necessity of perfecting the front-wheel suspension for the sake of the comfort of rear-seat riders; and, second, the advisability of providing an instantaneous, automatic variation of suspension flexibility in inverse proportion to the square of the speed of axle displacement. In the special suspension system now being built, the springs are exceedingly flexible and not subject to change. However, their action is controlled by a mechanical snubber controlled hydraulically so that the entire suspension realizes the second of the principles laid down. The scheme on which the snubber operates is described.

Kinematics of Laminated Springs. By H. S. Rowell. Published in *Engineering*, April 26, 1929, p. 505. [C-1]

In the opinion of the author the laminated spring has several distinct advantages over all other types; first, it acts in itself without additional locations or brackets; second, unlike helical and pneumatic springs, which usually require auxiliary fitments as guides, the laminated spring often is its own guide, and, third, an inherent virtue of the laminated spring is the automatic damping of oscillations due to interleaf friction.

One of the most extensive uses of the laminated spring as locator is in the automobile, where the springs often serve as the sole locations between the sprung and unsprung parts. This arrangement greatly simplifies construction but carries with it a disadvantage; namely, when the springs deflect, secondary motions are imposed on the axles and these cause relative movements in the steering and braking gear, and in the power transmission. When these relative motions are restricted, severe stresses may be set up, and, when these are given full play, much wear usually results.

In this paper the author analyzes these motions and, with the aid of diagrams, shows how, when the motions are correctly understood, it is usually easy to arrange other parts so that maximum freedom and minimum wear result.

(*Continued on next left-hand page*)

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Studebaker "8" President establishes twelve new stock car records—2044.8 miles in 24 hours.....1928

Flight to North Pole—*Capt. G. H. Wilkins*.... 1928

Washington, D. C., to Mexico City—*Col. Chas. A. Lindbergh*..... 1928

Oakland, California, to Australia—*3 hops—Capt. Kingsford-Smith*..... 1928

Trepassy, N. F., to Wales, England—*Amelia Earhart, Wilmer Stultz, Louis Gordon*.... 1928

Twice across the U. S.—Chrysler Imperial 80—*6,721 miles in 167 hours*..... .. 1927

New York to Paris—*Col. Chas. A. Lindbergh*.. 1927

New York to Berlin—*Clarence Chamberlin*.... 1927

New York to France—*Com. Richard E. Byrd*.. 1927

Winner of Dole Flight—Oakland, California, to Honolulu—*Art Goebel, Lieut. Davis*..... 1927

Flight to North Pole—*Com. R. E. Byrd*..... 1926

Winner of the Gold Cup—Motor Boat Race—*25 footer "Greenwich Folly"*..... 1926

1500 Miles in 70 hours—from John O'Groats to Monte Carlo—*Hon. Victor Bruce in A. C. (Stromberg Equipped)*..... 1926

All Three Winners Reliability Tour—*1st, Travel Air, Walter Beech, Pilot—2nd, Buhl-Verville-Custer—3rd, Wright J-4, Stinson, Pilot*..... 1926

116.88 miles on 1 gallon of gas—*Joyce in an A. C. (Stromberg equipped)* 1926

Economy Run—Los Angeles to Yosemite—*300 miles on 18 gallons—Duesenberg (Stromberg equipped)—Joe Bozzani*..... 1926

Packard Chris-Craft breaks all motor boat records in Detroit Sweepstakes—*150 miles—average speed 55.65*..... 1925

Teaser—40 ft. motor boat beats 20th Century—*150 miles in 2 hours 40 minutes*..... 1925

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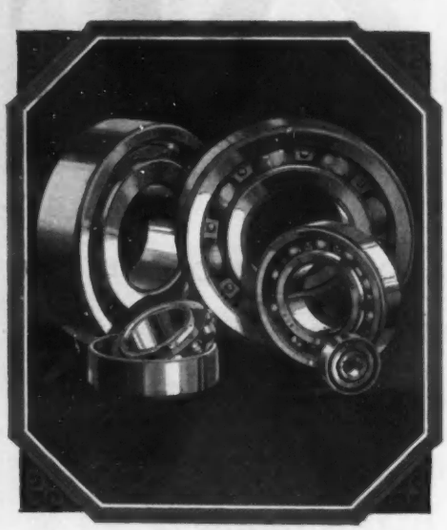

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Notes and Reviews

Continued

ENGINES

Entwicklung der Lorenzen Gasturbine. By B. Schulz. Published in *Der Motorwagen*, June 20, 1929, p. 355. [E-1]

The development of the Lorenzen gas turbine for the supercharging of engines is here traced. The origin of this device dates back to the war years.

Most attention is given to the exhaust-gas turbine developed first for aircraft use, and its construction and official test are described in detail. The more difficult problems involved in adapting the exhaust-gas turbine to automotive use are pointed out, and the results of 15 months' experience with it on a Mercedes car are summarized. The most important advantage gained is said to be the increased flexibility of the engine, which is evident particularly in starting and hill-climbing.

Compte Rendu de la Réunion du 8 Janvier, 1929. Published in Journal de la Société les Ingénieurs de l'Automobile, February, 1929; p. 518. [E-1]

Henri Petit was the first speaker in this meeting of the French society of automotive engineers, at which the topic for discussion was pistons. He emphasized the difficulty of adequately lubricating pistons in cold weather and recommended two remedies: mixing oil with the fuel or using a special oil that is not affected by low temperatures.

The next speaker, M. Ziembinski, took for his thesis the theory that all automotive pistons are too long, the usual construction being to provide two separate parts for the two functions of the piston; the head with its rings furnishing the fit and the skirt providing the support on the cylinder-walls. M. Ziembinski proposed to unite the two functions in the head of the piston, using the space between the rings as the bearing surface on the cylinder-walls. He tells how he would carry out such a scheme.

These views were opposed by M. Colmant, who avowed himself as of the old school and gave his reasons. R. de Fleury spoke of the interrelation between the piston and the engine and between the piston and the car, classified the forms of aluminum piston, and gave information on the aluminum alloys used.

Other speakers presented various aspects of piston design, giving, together with other information, results of experiments with different forms of piston and views on size standardization.

MATERIAL

The Stability of Metals at Elevated Temperatures. By Claude L. Clark and Albert E. White. Published by the Department of Engineering Research, University of Michigan, Ann Arbor, Mich.; 121 pp. [G-1]

This research was undertaken for the purpose of answering three questions: first, What relation, if any, exists between the results obtained from short-time tensile and long-time creep tests? second, What are the factors affecting the stability of metals at elevated temperatures? and, third, What mathematical relationship exists between the variables encountered in long-time testing?

With regard to the first, the conclusion has been reached that whether any relationship exists between these two forms of testing depends entirely upon the temperature range being considered.

Concerning the second problem, the conclusion is that the stability can be increased by increasing the strength of the weakest phase present, and that above the equi-cohesive temperature the amorphous phase is the weaker, while below that temperature the crystalline phase is the weaker of the two.

In answer to the last question, mathematical equations have been developed connecting stress and time for any particular tmperature and any particular metal.

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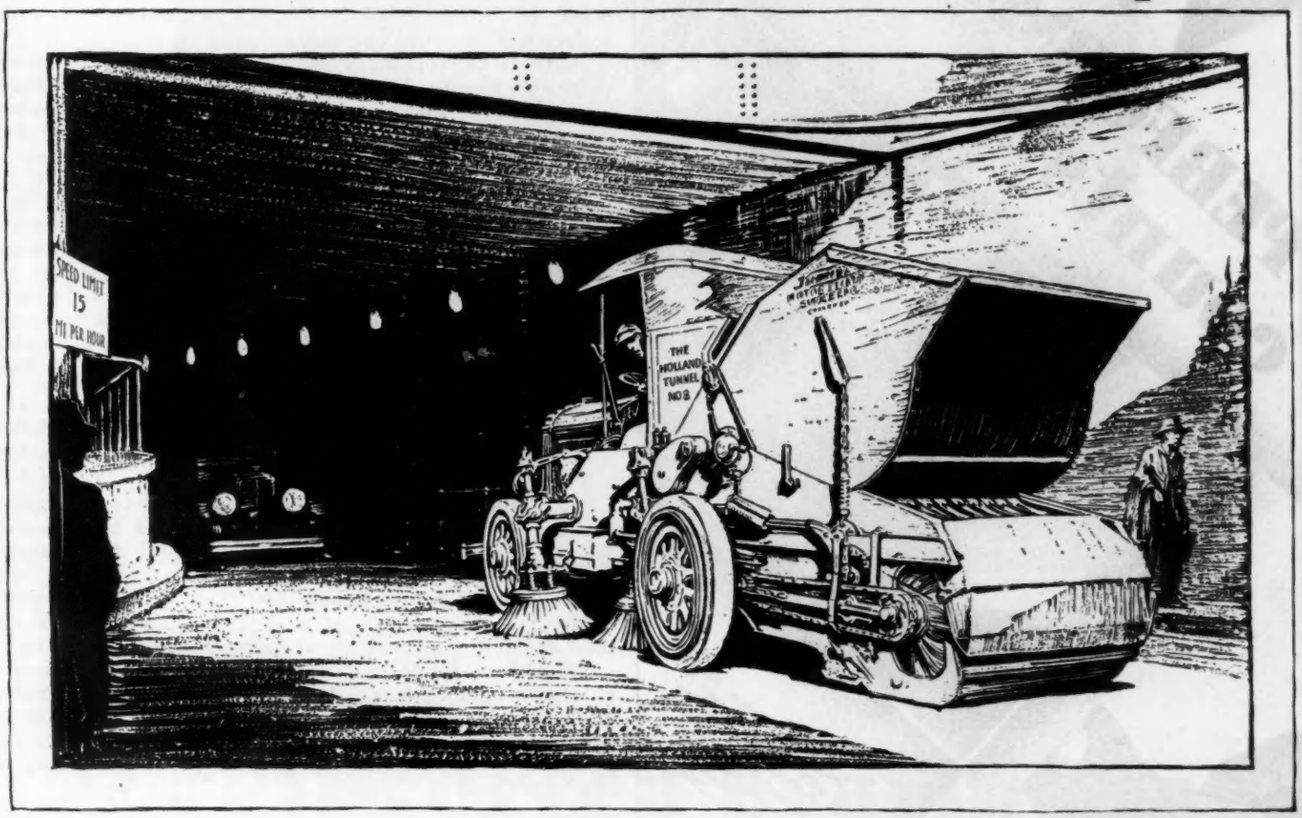
Cleaning the Holland Tunnel With Hercules Powered Sweepers



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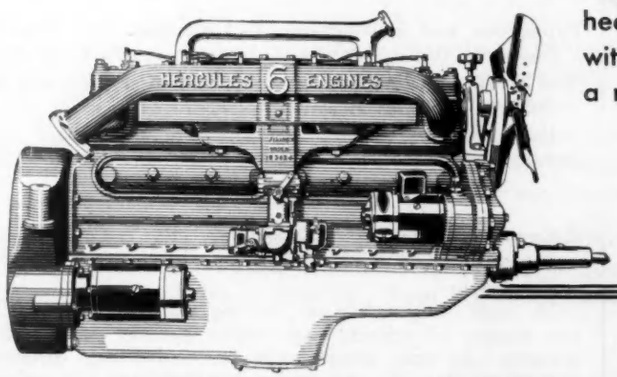

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Notes and Reviews

Continued

Corrosion of Metals Under Cyclic Stress. By D. J. McAdam, Jr. Preprint of a paper presented at the Annual Meeting of the American Society for Testing Materials at Atlantic City, N. J., June 24 to 28. [G-1]

Part I of the paper gives a brief resumé of previous work, an outline of the continued investigation, and a description of material and methods.

Parts II to VII, inclusive, discuss the effect of stress, time and number of cycles on corrosion. The resultant fatigue limit is used as a criterion of the effect of corrosion. The interrelationship between these four variables is illustrated by various types of two-dimensional diagrams and by a three-dimensional diagram. The metals investigated are ordinary steels, duralumin, monel metal and stainless iron.

It was found that for ordinary steels, and probably for duralumin, any stress cycle, however small the stress range, accelerates corrosion. For these metals, and probably for other easily corrodible metals, there apparently is no limiting stress below which the effect of cyclic stress on corrosion decreases abruptly. Whether there is such a limiting stress for monel metal and stainless iron has not yet been determined.

Conversion of Hardness Numbers, Part I. By Alfred Heller. Published in the *American Machinist*, April 4, 1929, p. 535. [G-1]

The author points out that the present conversion tables for Rockwell and Brinell hardness-tests check up very well for the Rockwell B-scale but show decided discrepancies when used on the C-scale, which covers the range from Brinell 244 (C-20) to Brinell 740 (C-68), including practically the entire range of heat-treated steels where the most exacting requirements as to hardness values are met.

The differences in results obtained by careful and reliable investigators is attributed to their effort to develop one conversion table for steel of all types. The results of tests conducted by the Wilson-Maeulen Co., makers of the Rockwell hardness tester, are given to prove the futility of this endeavor.

Laboratory Experiments on High-Temperature Resistance Alloys. By C. J. Smithells.

Corrosion at Discontinuities in Metallic Protective Coatings. By Ulick R. Evans, S. V. Williams, and J. W. Avery.

The Constitution of the Alloys of Aluminum with Copper, Silicon, and Iron. By A. G. C. Gwyer, H. W. L. Phillips, and L. Mann.

Die-Casting Alloys of Low Melting Point. By T. F. Russell, W. E. Goodrich, W. Cross, and ((in part) N. P. Allen.

Work-Softening of Eutectic Alloys. By F. Hargreaves, and R. J. Hills.

Die-Casting of Copper-Rich Alloys. By R. Genders, R. C. Reader, and V. T. S. Foster.

Properties and Production of Aluminum-Alloy Die-Castings. By S. L. Archbutt, J. D. Grogan, and J. W. Jenkin.

The Strength of a Cadmium-Zinc and of a Tin-Lead Alloy Solder. By C. H. M. Jenkins.

Papers presented last September at a meeting of the Institute of Metals, in Liverpool, England. [G-1]

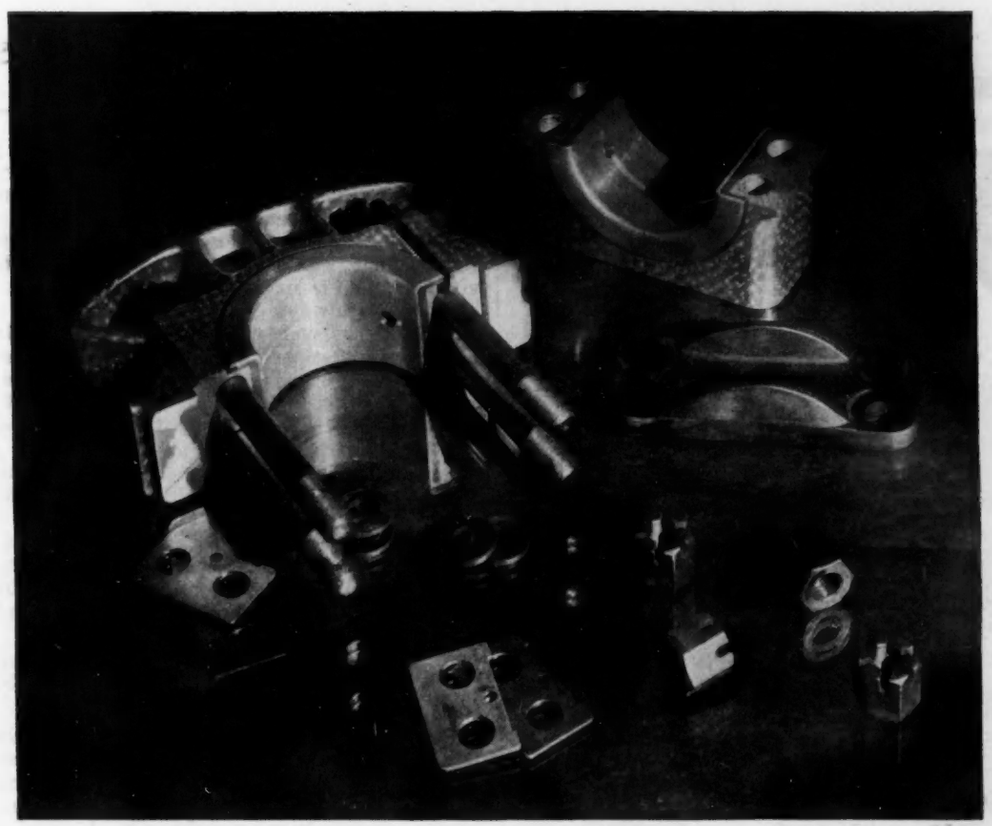
MISCELLANEOUS

Elementary Differential Equations. By T. C. Fry. Published by D. Van Nostrand Co., Inc., New York City; 255 pp. [H-3]

No such thing exists as "making mathematics easy," but the clarity of presentation varies greatly with different writers. In this small book on elementary differential equations, Dr. Fry has again demonstrated his ability in the art of writing mathematics tersely and clearly.

Written primarily for the out-of-hours courses at the

(*Continued on next left-hand page*)



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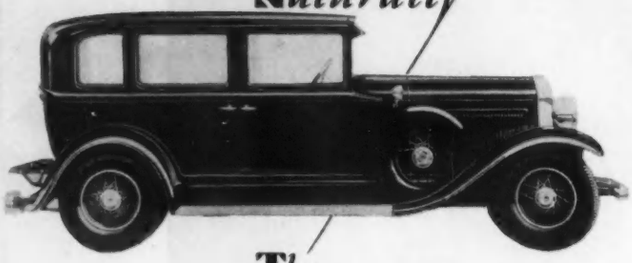

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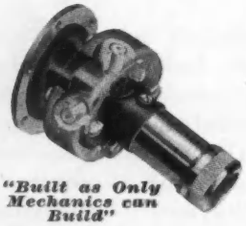

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Notes and Reviews

Continued

Bell Telephone Laboratories; that is, for practising engineers who have not had mathematical training beyond elementary calculus, the treatment does not aim to be rigorous in the sense in which pure mathematicians use that term. "Mathematics for mathematicians" is quite different from "mathematics for engineers"; this book is for engineers and is splendidly written from that standpoint.

Nor is it always elementary. Under the usual subjects dealt with in such works, Dr. Fry treats in considerable detail on operational methods which are specially suited to electrical engineering problems. The validity of operational methods applied to any system of simultaneous linear differential equations with constant coefficient and of the first order, and hence of any order, is demonstrated; from this demonstration the Heaviside expansion theorem, both in its original form and in its "generalized" form, follows immediately.

The last chapter provides an introduction to more advanced regions, such as integration in series and Bessel's equation. One wishes that the work would be supplemented by a more advanced treatise.—Benjamin Liebowitz.

Industrial Standardization. Published by the National Industrial Conference Board, Inc., New York City; 306 pp. **[H-3]**

This book undertakes to give a simple yet comprehensive exposition of the whole industrial standardization movement; that is, "first, to present a concise description of the working structure of the industrial standardization movement as it is expressed in the standardization work of individual concerns, engineering societies, trade associations and national and international standards organizations; and, second, to examine in the light of available evidence the authenticity of the numerous economic advantages claimed for standardization by its advocates, and to discuss some of the economic and social problems involved in the progressive extension of the standardization principle."

The very small amount of space that has been given to the standardization work of the Society in the automotive industry seems somewhat out of proportion to the accomplishments in this field. In 1910 the Society took over the standardization activities inaugurated by the mechanical branch of the Association of Licensed Automobile Manufacturers about five years before, and these activities have engendered and nurtured voluntary cooperative efforts among automotive engineers in a manner never before accomplished in any industrial group. It is generally recognized in America and abroad that the extensive and effective standardization accomplished by the American automobile industry has been an important factor in placing the industry at the head of world industries.

Production Planning. By John W. Hallock. Published by the Ronald Press Co., New York City; 172 pp., illustrated. **[H-5]**

The purpose of the book, as stated by the author in his preface, is to correlate generalized principles and fundamentals on production control with the material on practical working methods. Mr. Hallock contends that the organization and direction of production constitute clearly a technical engineering subject and therefore should lend itself to the same scientific and mathematical treatment that has been adopted in problems of the design and operation of equipment.

The writer has had considerable experience in teaching engineering students, and the material in this book is the outgrowth of a series of lectures delivered during a period of seven years, with revisions and amplifications made on the advice of manufacturing executives and men in industrial positions.

Some of the topics covered are: planning, estimating for

(*Concluded on next left-hand page*)

....particularly in the Automotive Industry

Mahon Automatic Oven Doors, for use in connection with production line work on automobile bodies, were developed as a measure of heat conservation. These doors also provide a great saving in labor — being opened and closed automatically by contact with conveyor trucks.

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Notes and Reviews

Concluded

production, determining machine capacities, computing process times and material handling.

Successful Shop Management. By "Twenty Experienced Shop Managers." Published by The Industrial Press, New York City; 204 pp. [H-5]

This small volume endeavors to cover a rather comprehensive field, some of the topics being: production and management methods, equipment, cost systems, personnel problems, patents, and sales. Therefore the treatment of each is of necessity very brief. The contributors are not named but the preface states that the information given is based upon the practice in well-managed shops and manufacturing plants which have demonstrated that they know how to convert raw materials into finished products by direct efficient methods which conserve energy and time.

PASSENGER-CAR

Considerations sur le Grand Prix de l'A.C.F. By Marc Chauvierre. Published in *La Vie Automobile*, June 10, 1929, p. 195. [L-1]

That amateurs have been permitted to enter the classic racing event in France, the Grand Prix of the Automobile Club of France, is greatly deplored by the author. He believes that such entrants, not having the capital to finance the development of a suitable vehicle, may prove detrimental to the success of the race by impeding the progress of the more suitable and better prepared cars.

The author briefly sketches the development of the rules for the event, pointing out that the restriction of cylinder capacity led to concentration on high-speed engines of low thermodynamic efficiency and lack of flexibility. The present rules, limiting fuel and oil consumption and setting a minimum car-weight and size, are commended as likely to lead to developments of significance in commercial practice. In his comment on the technical possibilities likely to be instigated by such regulations, the author emphasizes the probability of a return to the large-cylinder flexible engine, a trend in consonance with popular desire.

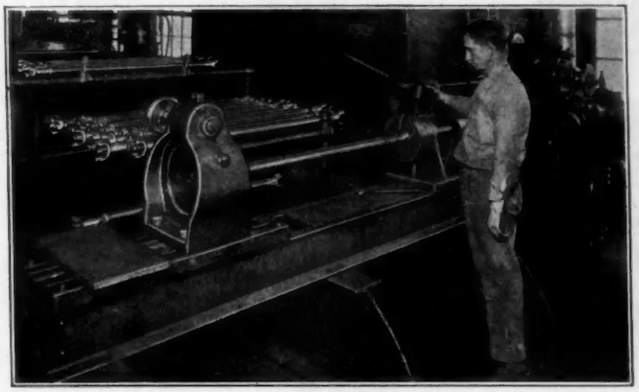
A description is given of the cars entered, most space being devoted to the Peugeot and Bugatti cars, which, besides being the most powerful contestants, represent two opposed types of design; the Peugeot being a relatively low-speed engine of large cylinder capacity without a supercharger, and the Bugatti a small high-speed engine with a supercharger.

Automotive Grinding. By Fred B. Jacobs. Published by the Penton Publishing Co., Cleveland, Ohio; 146 pp., illustrated. [L-5]

The author, who has written several other volumes on various angles of the subject of abrasives and grinding, has prepared this book as a reference work for superintendents, abrasive engineers, grinding-room foremen, grinding-machine operators, and students of abrasive engineering methods, to serve as a standard of the best latter-day practice. The grinding practice in the automotive industry has been chosen as a criterion of economical manufacturing methods as applied to intensive production, since motor-car manufacturing plants in the United States rank as the largest consumers of abrasive materials in the world.

Abrasive materials are discussed in the first chapter and a list of the various trade names of grinding-wheels giving the material from which the wheel is made, and the maker's name is appended. The following chapters cover the various types of abrasive machine, cylinder and piston finishing, camshaft and crankshaft grinding, internal, centerless, disc and surface grinding, with separate chapters devoted to automobile body finishing and grinding-wheel supervision. An unusually large number of photographs of the various operations enlivens the text, and a complete index makes it a useful reference book for the grinding processes.

SILVER ANNIVERSARY YEAR
1904 1929



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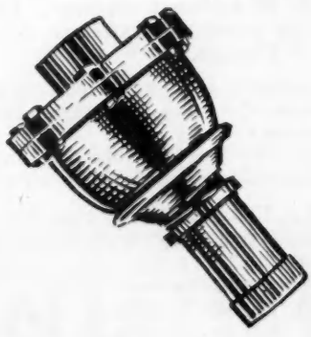

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ST. PAUL—Merchants National Bank Building
ST. LOUIS—International Life Building
KANSAS CITY—Reliance Building

Personal Notes of the Members
Continued

of Los Angeles, has joined the sales engineering force of A. E. Feragen, Inc., in Seattle, Wash.

Raymond M. Anderson recently severed his connection of more than 10 years' standing with the Holley Carburetor Co., of Detroit, with which he held the position of director and chief engineer. He plans to take a rest in New England, where he will carry on some special carbureter work.

Charles S. Ash, previously a consulting engineer, with headquarters in Detroit, for the Wire Wheel Corp. of America, has accepted a position in the engineering department of the Kelsey-Hayes Wheel Corp., located at Detroit.

Erwin L. Bare is now serving the Hayes Body Corp., in Grand Rapids, Mich., as production engineer. For the last three years he has acted in a similar capacity for the Murray Corp. of America, in Detroit.

Herbert Baxley lately resigned as instructor in mechanical engineering at Pratt Institute, of Brooklyn, N. Y., to join the Vacuum Oil Co., in New York City. He will be located in the refined-oil department of the engineering division, and his new work will be in connection with the quality control of fuels.

Wellwood E. Beall, a former student at New York University, has been employed by the Walter M. Murphy Coach Co., at Pasadena, Cal., as assistant aeronautical engineer.

Harry G. Blanchard has accepted the position of factory manager of the Smith & Sons Corp., located at Buffalo. Prior to establishing this connection he acted in a similar capacity for the Chanslor & Lyon Tire & Rubber Co., of Oakland, Cal.

William M. Britton recently announced his appointment as chief engineer of the Aero Engineering & Advisory Service, Inc., located in New York City. Prior to making this connection he was general manager and consulting engineer of the Aero Service Co., in Los Angeles.

William G. Brown has resigned the post of assistant professor of aeronautics at the Massachusetts Institute of Technology to become affiliated with the Daniel Guggenheim Fund for the Promotion of Aeronautics, in New York City.

Charles D. Cathcart at present is doing special engineering work for C. Fuller, president of the Richfield Oil Co. of California. He formerly served the Dunn Mfg. Co., of Oxnard, Cal., as mechanical engineer.

Harold Chalk, until lately employed as teaching assistant in the University of Michigan, has accepted the position of research engineer with the Ethyl Gasoline Corp., in Yonkers, N. Y.

Dudley Chambers has resigned the post of assistant chief engineer of the Universal Motor Co., at Oshkosh, Wis., to establish a connection with the Bendix Brake Co., of South Bend, Ind.

Einar A. Comfield is now serving the Available Truck Co., Chicago, as assistant engineer. Prior to making this connection he acted as draftsman for the Package Car Corp., also of Chicago.

It is regretted that an erroneous statement was made in the April issue of the S.A.E. JOURNAL regarding the connection of **Thomas Cordery.** Mr. Cordery was and still is affiliated with the General Motors (Australia) Proprietary, Ltd., as Vauxhall service representative in Melbourne.

Raymond J. Cox recently entered the service of the Keystone Aircraft Corp., of Bristol, Pa., as a designer. Previously to accepting this position he acted in a similar capacity for the Miller Corp., in New Brunswick, N. J.

Leonard R. Cuttler, who until recently was body draftsman for the Pierce-Arrow Motor Car Co., at Buffalo, has become identified in a similar capacity with the Chrysler Motor Corp., of Detroit.

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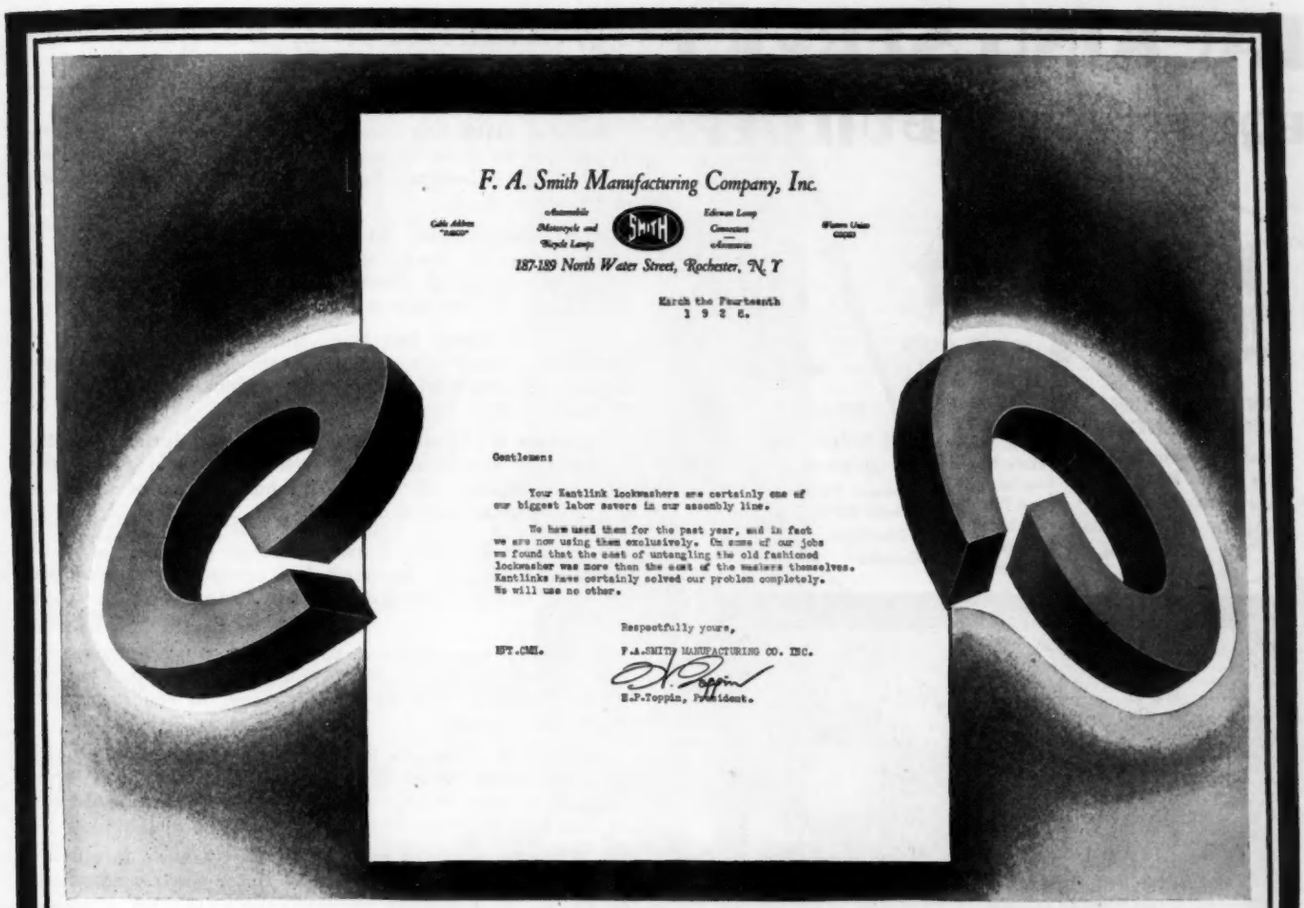
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Please read this letter carefully—it is one of many from manufacturers who are saving money by using Kantlink.

Ask us for other letters and additional information if you are still in doubt. Eventually you will agree that *you can not afford to use anything but Kantlinks.* They save more than their entire cost for many manufacturers.

They do not rust, and stain your finished job. They have greater holding power.

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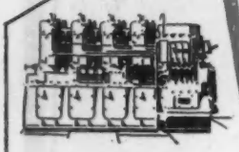
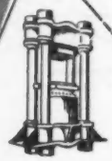


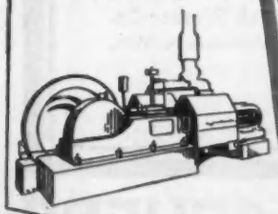
INTERNAL COMBUSTION ENGINES
Metal or Fibrous Packings for Piston Rods, Fuel Valves, Water Pumps. Oil Wiper Packing and Gaskets.

STEAM SHIPS and MOTOR BOATS
Packing for Pistons Rods and Valve Stems on Main Engines, Auxiliaries and Pumps. Gaskets for all Purposes



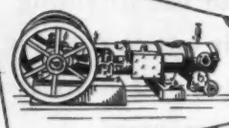
HEAVY MACHINERY
Hydraulic Plunger Packing and Steam Packings. Gaskets

STEAM ENGINES
Piston Rod and Valve Rod Packing. Oil Wiper Packing. Gaskets cut from Compressed Asbestos Sheet. Metal and Fibrous Packings of every Description

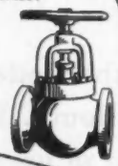


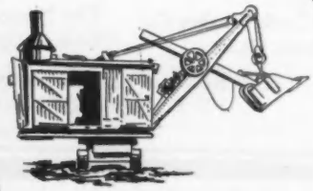
STEAM or MOTOR-IZED SHOVELS and DREDGES
Piston and Valve Rod Packings. Water Pump Packings. Compressed Asbestos and Rubber Gaskets

AIR or GAS Compressors
Metal or Fibrous Packings for Piston Rods. Oil Wiper Packing and Gaskets



VALVES
Shredded Metal or Fibrous Packing for Valve Stems. Gaskets and Valve Disc.





WRITE FOR GENERAL CATALOG

THE GARLOCK PACKING COMPANY
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Personal Notes of the Members
Continued

Rudolph Daub has resigned as designer for the Durant Motor Co. of New Jersey, at Elizabeth, to become aeronautic engine designer for the Wright Aeronautical Corp., in Paterson, N. J.

Michel Degremont, formerly engineer-designer for the Bragg-Kliesrath Corp., of Long Island City, N. Y., has joined the Hugh M. Rockwell Aircraft Engine Co., Freeport, L. I., in a similar capacity.

George E. Denis has been made chief engineer of the Universal Motor Co., at Oshkosh, Wis. He previously worked on industrial and marine engines for the Buda Co., of Harvey, Ill.

Raymond W. Dyer recently assumed the duties of factory manager of the Industrial Development & Mfg. Corp., in Portland, Maine. He previously had charge of inspection at the American Cirrus Engines, Inc., Belleville, N. J.

Ferdinand F. Fick, formerly chief engineer of A. P. Schraner & Co., in Cleveland, has accepted a similar position with the Western Reserve Air Motors Corp., of Lakewood, Ohio.

A. Flower has resigned as general works manager of Guy Motors, Ltd., in Wolverhampton, England, to join Trojan, Limited, of Croydon, England, in the capacity of production manager.

Oscar E. H. Froelich has resigned his position as chief engineer for the Ward Motor Vehicle Co., of Mount Vernon, N. Y., to become transportation engineer for the Ward Baking Co., in New York City.

L. H. Gates recently gave up his position as foreman of engine test with the Pierce-Arrow Motor Car Co. to assume the duties of assistant superintendent of the Atterbury Motor Car Co. Both companies are located in Buffalo.

Herbert Gfroerer, previously identified with the commercial car and truck division of the Dodge Brothers Corp., of Detroit, as assistant director of sales, has joined the Olds Motor Works, of Lansing, Mich.

George Glitzenhirn, who formerly gave instruction in machine-shop practice and the elements of production at the University of Michigan, has joined the Leeds & Northrup Co., in Philadelphia.

Frederick L. Green has entered the service of the Gemmer Mfg. Co., of Detroit, as experimental engineer. Prior to accepting this position, he was research engineer for the General Motors Corp., also of Detroit.

V. F. Halliburton, formerly purchasing agent for the Spartan Aircraft Co., of Tulsa, Okla., has been assigned the duties of pilot salesman for the company.

R. W. Hautzenroeder is now acting as designer and assistant to the chief engineer in the tractor division of the W. A. Riddell Co., of Bucyrus, Ohio. Previous to making this connection he was engine and tool designer with the Steel Products Engineering Co., located at Springfield, Ohio.

Ray E. Hoffman, a Purdue University student, is doing experimental work for the Auburn Automobile Co., of Auburn, Ind.

W. King Jenkins has severed his connection with the Aeronautical Engineering Co., in San Francisco, to take up the duties of chief engineer of the aeronautical division of the Gruss Air Spring Co. of America, also located in San Francisco.

Otto H. Jensen, who until lately was research engineer for the Bossert Corp., in Utica, N. Y., is now a member of the engineering staff of the Ternstedt Mfg. Co., in Detroit.

Alexander S. Kalozi recently resigned as sales engineer for the Relay Motors Corp., in Lima, Ohio, to become sales

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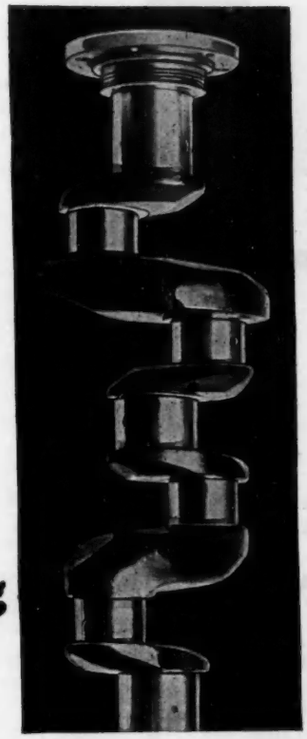
A Message to Production and Engineering Officials.....



Two leading manufacturers of automobiles have already adopted Normalized Carbon-Vanadium Steel crankshafts. Their freedom from strains and warpage assures a true-running shaft which, when once balanced, remains perfectly balanced.

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of vanadium, silicon, chromium, silico-manganese, tungsten and molybdenum, produced by the Vanadium Corporation of America, are used by prominent steel makers in the production of high-quality alloy steels.

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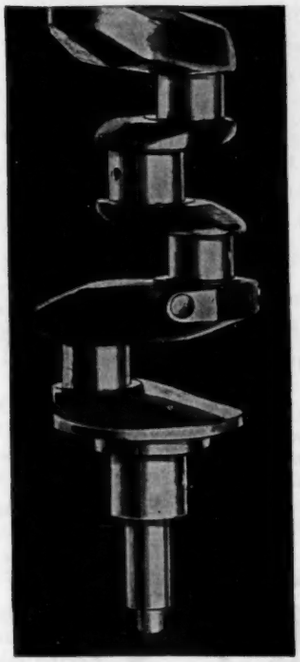

In normalized condition, Carbon-Vanadium Forgings show minimum yield point of 70,000 lbs. per square inch, ultimate strength of 100,000 lbs. per square inch, 20% elongation in 2 inches, 45% reduction in area, and Brinell hardness range of 196—217. Because Carbon-Vanadium Forgings are not subject to any quenching operations, they are free from drastic cooling strains and, therefore, require no cold-straightening during machining.

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VALPARAISO, INDIANA

Personal Notes of the Members

Continued

representative for the Motor Tool Specialty Co., in Cleveland.

Marion H. Kapps, who previously studied at Purdue University, has entered the service of the General Motors Proving Ground, at Milford, Mich., as assistant field engineer.

Theodore Kargau, now director of budgets for the Wright Aeronautical Corp., in Paterson, N. J., was formerly production engineer of the Victor Talking Machine Co., in Camden, N. J.

Edwin Karlson recently gave up the post of factory manager of the Chandler-Cleveland Motors Corp., in Cleveland, to join the Marmon Motor Car Co., at Indianapolis, as general works manager.

Oliver K. Kelley has been transferred from the engineering department of the Cadillac Motor Car Co., of Detroit, to the new developments division of the General Motors Truck Co., at Pontiac, Mich., where he will assume the duties of designing engineer.

J. M. Klements has joined the Baker-Raulang Co., of Cleveland, as body draftsman. He used to act in a similar capacity for the Studebaker Corp., of South Bend, Ind.

Russell E. Knox, a former engineering student at Ohio State University, is now with the American Telephone & Telegraph Co., at Cincinnati, as a student engineer.

Kenneth M. Lane has been named chief engineer of the Aeronautics Branch of the Department of Commerce in the City of Washington. He formerly held the post of chief airplane engineer for the Wright Aeronautical Corp., at Paterson, N. J.

Dana W. Lee, who recently graduated from Cornell University, is serving the National Advisory Committee for Aeronautics Laboratories, at Langley Field, Va., as junior mechanical engineer.

Warren P. Loudon, formerly identified with the engineering department of the Delco-Remy Corp., of Anderson, Ohio, has been named president and general manager of the Delco Aviation Corp., in Dayton.

Announcement was recently made of the appointment of **William H. Mallon** as technical executive of the Aeronautical Chamber of Commerce of America, Inc., in New York City.

M. Lowrie McCandless, Jr., recently relinquished his position of statistical engineer with the Chandler-Cleveland Motors Corp. to enter into a connection with the Cleveland branch of the Ford Motor Co., for which he will act as sales and service-school instructor and special representative.

David McWhir, who has been associated with the Wright Aeronautical Corp., of Paterson, N. J., for the last 12 years, recently announced his resignation. For the last five years he acted as purchasing agent for the corporation.

S. Menton, now serving the Limousine Body Co., in Kalamazoo, Mich., as body engineer, used to act as production engineer for the Chrysler Corp. of Canada, at Windsor, Ontario.

S. Lester Milliken, formerly identified with the engineering department of the International Harvester Co., at Springfield, Ohio, has established a connection with the King-Seeley Corp., of Ann Arbor, Mich.

Fritz Mitschke recently left the service of the Kearney-Trecker Corp., in Milwaukee, for which he acted as tool designer, to accept a similar position with the Waukesha Motor Co., of Waukesha, Wis.

George Otto Noville has been employed by the Marchetti Motor Patents, Inc., of San Francisco, as technical supervisor. He used to be aeronautical engineer for the Standard Oil Co. of California, also located in San Francisco.

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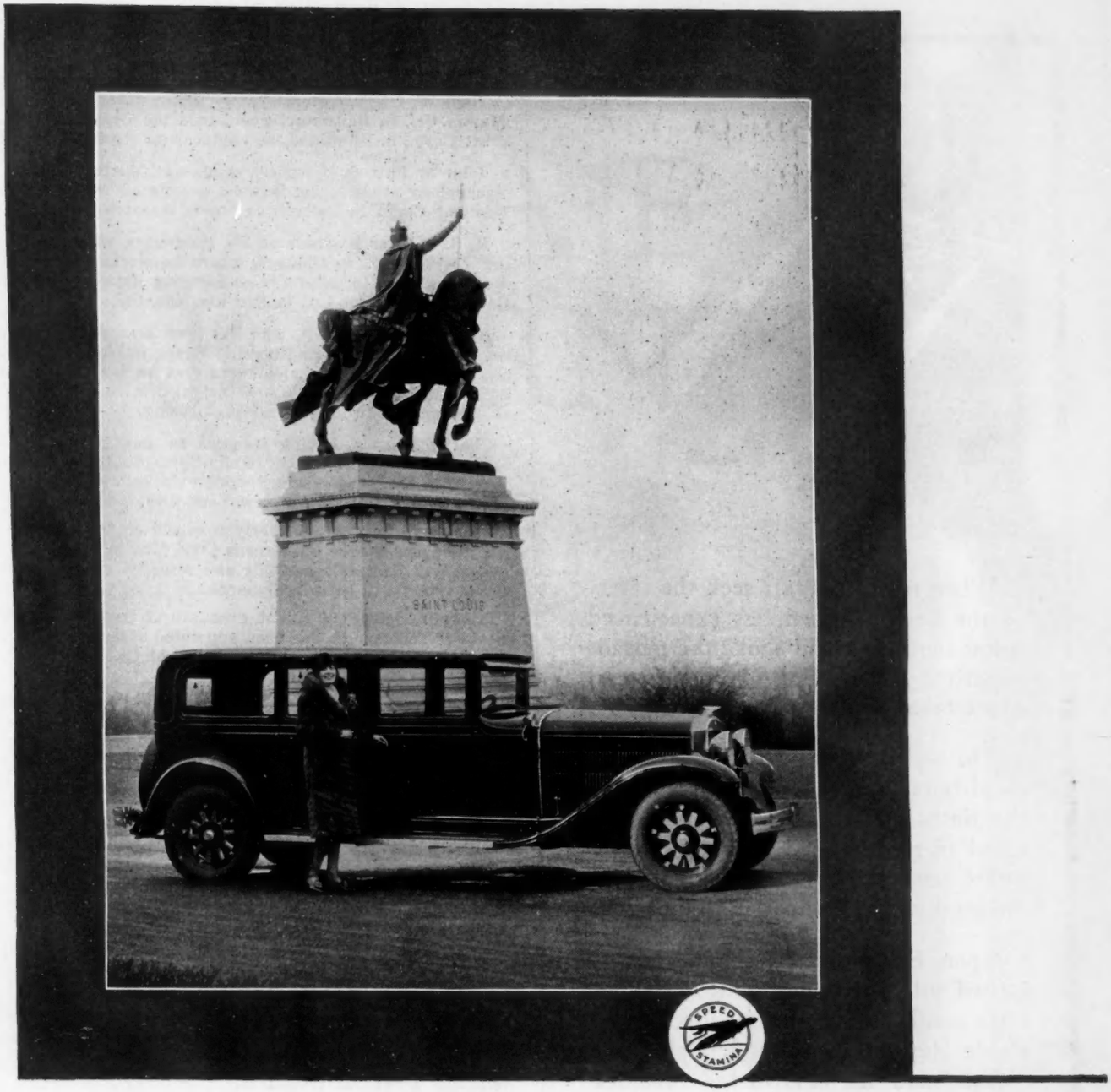
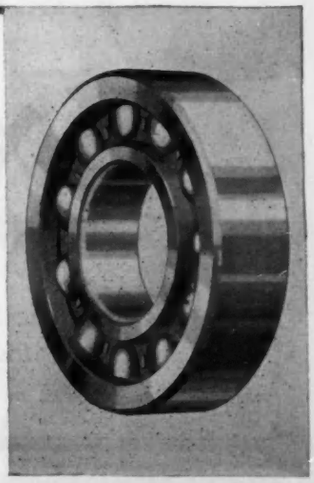


AMONG the many indications of the careful planning of Gardner engineers . . . . that performance may fulfill the expectancy that beautiful exteriors excite . . . . are New Departure Ball Bearings . . . . The New Departure Mfg. Company, Bristol, Connecticut.

NEW DEPARTURE

BALL BEARINGS



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When other aircraft seek the safety of the hangar, when less experienced pilots look aloft and shake their heads negatively, the pilot of the airmail plane takes off.

Through darkness, fog and storm, steadily he wings his way, for there on the dash before him, clearly illuminated in the shielded glow of electric lights, are the instruments—the eyes of the pilot who is compelled to fly blind.

Upon Exide Batteries hundreds of skilled pilots pin their faith. Behind their confidence is the recollection of Exide dependability under all conditions, and the knowledge that for more than 41 years Exide Batteries have been built for every purpose where storage battery power is used.

Exide
BATTERIES

The Electric Storage Battery Co.
Philadelphia

Exide Batteries of Canada, Limited, Toronto

Personal Notes of the Members

Concluded

John W. Overbeke, until lately designer for the Glenn L. Martin Co., in Baltimore, has joined the Great Lakes Aircraft Corp., in Cleveland, as engineer on stress analysis.

John S. Patrick, formerly a Massachusetts Institute of Technology student, has become associated with the Ethyl Gasoline Corp., in Detroit, as junior research engineer.

R. S. Pfeiffer has severed his connection with the Western Electric Co., in Chicago, where he worked as development engineer, to enter the engineering department of the Caterpillar Tractor Co., in San Leandro, Cal.

Reginald J. S. Pigott, who has been connected for some time with the Smoot Engineering Corp., in New York City, as consulting engineer, announces that he has made a connection with Stevens & Wood, Inc., also in New York City, as a consultant in mechanical engineering.

Charles Samson, having resigned as manager of the accessory department of the Kelly-Springfield Tire Co., in New York City, has assumed similar duties with the United States Rubber Co., also in New York City.

Charles E. Sargent, formerly research engineer with the Witte Engine Works, in Kansas City, Mo., has entered the independent field as consulting and research engineer. His headquarters will be in Indianapolis.

James H. Seibert, a recent graduate of the Carnegie Institute of Technology, has been appointed assistant publicity director for the Chicago Pneumatic Tool Co., at Franklin, Pa.

George K. Spalding has resigned his position as eastern district superintendent of motor transport with the Pure Oil Co., of Chicago, to take up duties in the service department of the Autocar Sales & Service Co. His headquarters will be in Chicago.

F. M. Starling recently announced his acceptance of the position of general manager and vice-president of the Refiner-Consumer Stations Co., Inc., of Fort Worth, Texas. Previous to making this connection he had charge of the lubricating-oil, fuel-oil and asphalt division of the Standard Oil Co. of New York, in New York City.

Charles R. Staub has severed his connection with Dodge Brothers, Inc., of Detroit, as gear engineer, and is now associated with the Michigan Tool Co., of the same city, as gear and service engineer.

A. J. Subasky, formerly machine designer with the Poole Engineering & Machine Co., at Baltimore, is now serving the Glenn L. Martin Co., also of Baltimore, as designer.

Maurice A. Thorne is now engaged in experimental engineering for the Pierce-Arrow Motor Car Co., of Buffalo. His last previous connection was with the Studebaker Corp. of America, at South Bend, as superintendent of the proving ground. Mr. Thorne is the author of a paper entitled Notes on Crankcase Corrosion, which appeared in the January, 1926, issue of the S.A.E. JOURNAL.

Franklin O. Vogelsang, a former Ohio State University student, has been employed by the Aluminum Co. of America at its New Kensington, Pa., plant as engineering apprentice.

Ernest K. von Brand is now acting in the capacity of research engineer for the dynamics section of the General Motors Research Corp. Laboratories, in Detroit. He was previously associated with the Inland Mfg. Co., in Dayton, Ohio.

Carl Voorhies, until recently engineering representative in production for the Studebaker Corp., at South Bend, Ind., has joined the Pierce-Arrow Motor Car Co., at Buffalo.

T. A. Weir, formerly identified with the Union Pacific Railroad Co., at Omaha, Neb., is now acting in an engineering capacity for the Vacuum Oil Co., in New York City.